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WAR BALLOONS.

AEROSTATION, which has made so much progress during the last ten years—thanks to the persevering efforts of ardent experimenters—and which is destined to render so many services as soon as science will have solved the problem of a dirigible balloon, is of French origin, and its first application to the art of war dates back to the revolution. But there is a wide difference between the captive balloons of that epoch and those that modern armies will use in campaigns for ascertaining the movements of the enemy. We can proudly say that France is to-day still ahead in the matter of war balloons.

Italy, in her war with Abyssinia, having need of light and easily transportable balloons, capable of being quickly inflated on the spot, was obliged to address a skillful French manufacturer, Mr. Gabriel Yon. The problem was a delicate one to solve.

Abyssinia is not a country in which the gas necessary for the inflation of balloons can be easily procured. It was necessary to provide an apparatus for the production of the gas, and to find a fit means of transporting it across the desert.

As we shall see, these difficulties have been surmounted in a very simple manner by Mr. Yon, who, before the balloons started for Massowah, performed some very conclusive experiments at his works, near the Champ-de-Mars.

One of our engravings represents the ascent of one of the balloons as it occurred in the yard of the works. The inflation has just been effected, and the balloon, held by a rope attached to a windlass, is swaying in the air. In countries provided with gas works, the inflating is usually effected by means of illuminating gas, and it is only necessary to connect the balloon with one of the city mains. In the case under consideration, the gas, produced by a process which we shall speak of further along, was contained in forty tubes, united in two groups of twenty, with a barrel that supplied the conduit, which, in our engraving, ends at the place where the balloon is located in the center of a circle of ballast bags.

Around the drum of the windlass winds the cable, the extremity of which is affixed to a trapeze that surrounds the car. Within the cable, which is of several strands, there are two telephone wires, which are not exactly in the center, but a little to one side, in order that, in case of a breakage, the point where the accident occurred may be known at once. By this means the balloon is constantly in communication with those who remain below, and who can instantaneously pay out or draw in the cable at will. It takes ten men to do the maneuvering, the traction to be exerted not exceeding 650 pounds in a pretty swift wind, and but 325 pounds in a dead calm.

These balloons are wholly of silk, and are so pliable that each fits into its car, which has a capacity of but 35 cubic feet. The whole is contained in a compartment in the hind carriage of the vehicle, the front part of which is occupied by the windlass. The carriage is very low, and is built to withstand shocks and jolting. It requires but two horses to draw it, since the whole weighs but about 1,425 pounds.

The hydrogen is prepared in a special apparatus which we illustrate herewith. This apparatus, which is quite cumbersome, cannot be carried everywhere, and so in certain cases the gas must be carried all prepared. In order to reduce its volume, the idea has occurred to compress it under very great pressure into very strong steel cylinders. Each of these latter weighs 65 pounds, and is 8 feet in length, 5 inches in diameter, and ⅕ an inch in thickness. The gas is preserved therein, without any loss, at a pressure of 135 atmospheres. It takes from seventy to seventy-five of these cylinders to inflate a balloon of 10,500 cubic feet. They are borne upon another carriage, and, as their total weight is between 4,400 and 5,000 pounds, they can be easily hauled by three horses.

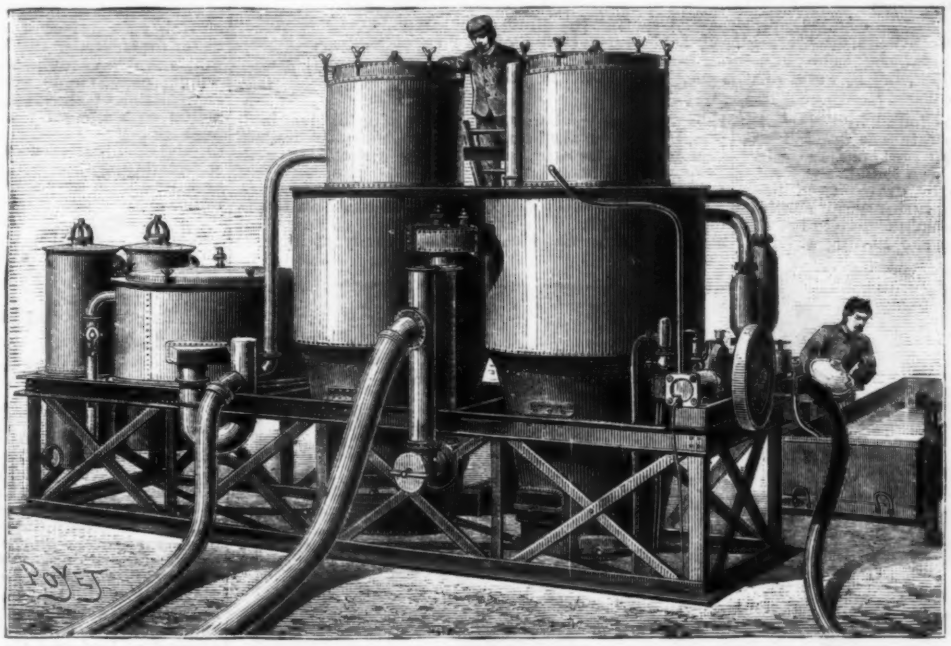
In Abyssinia, when the land does not allow of the passage of a vehicle, these cylinders will be carried upon the backs of camels, as shown in our engraving. In the operation of inflating, but one cylinder is opened at a time, since the gas, in passing from 135 atmospheres to 1 atmosphere, would produce through its expansion an intense cold, and so, in order not to cool it, it is necessary to operate successively cylinder by cylinder.

We now come to the manufacture of the hydrogen gas in the apparatus of which we have spoken.

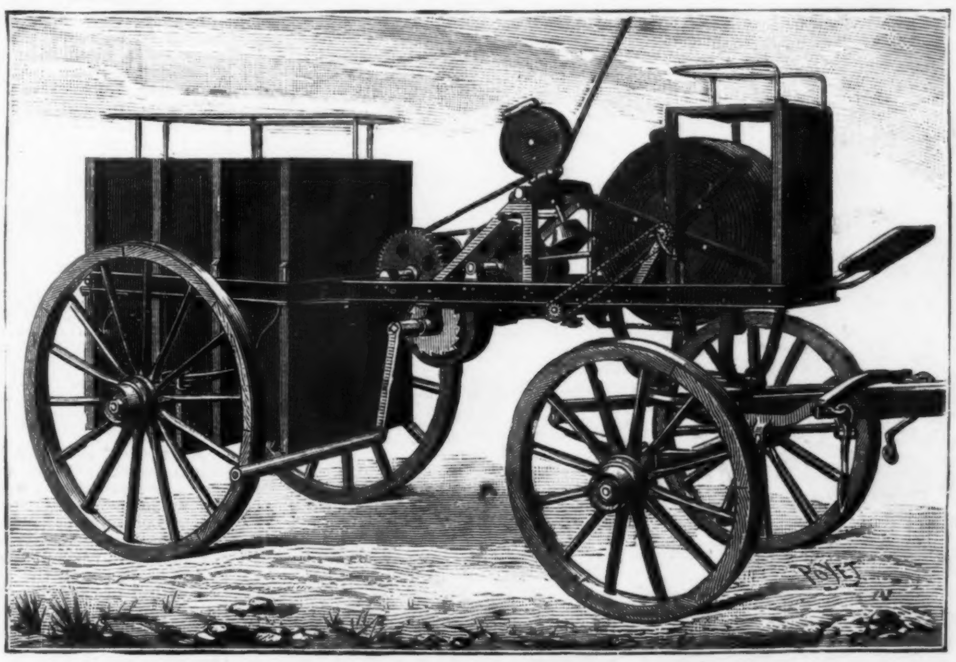
Iron filings immersed in diluted acid are placed in two large generators. The gas formed by the decomposition of the iron escapes through a pipe fitted to each generator, and passes into a large vessel filled with water, and called a purifier, where it is freed from all its impurities. It then ascends in a conduit, whence it makes its exit ready for use, and to be stored in the steel cylinders. This gas generator, which is very simple, can be easily transported to the vicinity of the field of operations of an army.

Mr. Yon is now likewise constructing for the Russian government a dirigible steam balloon, 190 feet in length by 40 in width. Its dimensions are the sole datum that we have been able to obtain concerning it, for the secret seems to be carefully kept.

As well known, all the great European powers are deeply occupied with war aerostation. What has become of our aeronautic experiments of the Meudon school? Is Commander Renard continuing his experiments? Is the great balloon that was to succeed the electric one ready? We do not know. There is every reason for making haste. While our neighbors are preparing with so much activity, would it not be well for us to be as ready as possible, since war may break out on a sudden?—*L'Illustration.*



MILITARY BALLOONING—THE GAS GENERATOR.



MILITARY BALLOONING—THE ROPE CARRIAGE.

ON THE ACTION OF BOSTON WATER ON CERTAIN SORTS OF SERVICE PIPE.*

By the late WM. RIPLEY NICHOLS, Member of the Boston Society of Civil Engineers, and L. K. RUSSELL.

ALTHOUGH galvanized pipe is used to a considerable extent for distributing soft water, and although the general nature of the action of water upon zinc is known, there are very few results of quantitative analysis accessible which show the amount of zinc actually taken up by the water under the circumstances of ordinary practice. We have recently made some experiments in this direction.

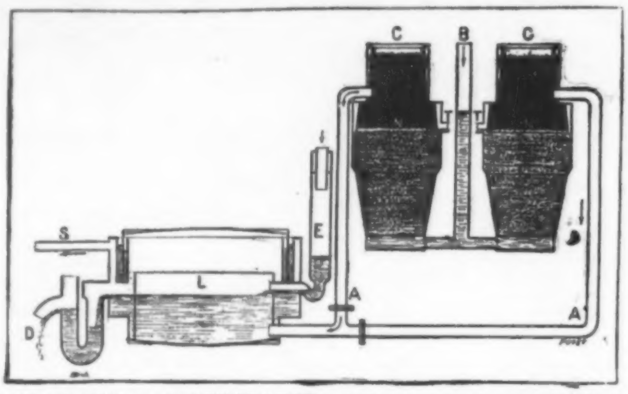
The principle on which the so-called "galvanizing" process rests is that, under ordinary circumstances, zinc is slightly electro-positive to iron, and if the two metals in intimate contact are simultaneously immersed in water, the zinc will be acted upon rather than the iron. This principle is only partially realized in practice. As long as the zinc coating is perfect, the iron is protected; but if the zinc coating be imperfect, or if it be removed, as it is liable to be in coupling pipes together, then the iron is acted upon as well and compounds of zinc as well as of iron are formed and carried forward with the water, or form a sediment which gradually chokes up the pipe. One of us has already stated elsewhere, as the result of experience, that it will usually be found possible to detect zinc in water which has passed through any considerable length of zincked pipe, and has expressed the opinion that with most waters which are used for water supply the amount of zinc in suspension—generally a hydrocarbonate—and in solution (in whatever form) is too inconsiderable to form the basis of a sanitary objection to the use of the pipe.

In our recent experiments we employed a length of about thirty-nine feet of half inch galvanized pipe connected with the water service of the building in such a way that the water in the pipe could at any time be displaced by fresh water without allowing air to enter. Usually for a test an amount of water was drawn off equal to or slightly greater than the capacity of the pipe. The experiments were continued during a period of three months. We found zinc in solution and in suspension, in not widely varying amounts, whenever water stood in the pipes from seven to seventy hours.

* Read October 19, 1887, by Prof. L. M. Norton.

Water standing several days in the pipe contained no greater proportion of zinc in solution, though that in suspension was increased, and at the end of the three months the quantity of zinc found was only slightly less than at the beginning.

The water contained in solution 0·3 to 0·6 part per 100,000 zinc. In suspension 1·5 to 2 parts per 100,000, or 0·3 grain per gallon in solution, and 1·0 grain per gal-



PLAN OF THE GAS GENERATOR.—C C, gas generators containing iron filings and diluted acid. B, pipe for distributing the dilute acid in the generators. N, level of the acid. T, tubes for carrying off the spent acid. A, entrance for the gas coming from the generators to be washed in the purifier, L. E, water for the gas. S, exit for the washed gas.

lon in suspension. No zinc was found in water with the regular flow, but when the rate was decreased to about one quart per hour, 0·9 part per 100,000 of zinc in solution *and* suspension was found.

The inevitable inference to be drawn from these results is that the zinc coating is slowly but continuously dissolved, and it becomes a question of interest to consider the length of time the coating will last. Some experiments on the thickness of the zinc coating and the depth to which it penetrates the iron were made.

Some rods of wrought iron about six inches long were carefully centered and turned off by a lathe for about four inches of their length. The diameters of these were measured with a micrometer screw caliper measuring to one one-thousandth of an inch. The rods were now treated exactly as iron pipe is galvanized, *i. e.*, by dipping the iron, previously cleaned by immersion in muriatic acid, into a bath of melted zinc, with frequent additions of sal-ammoniac, the centering being preserved by filling the holes with putty, which was afterward easily dug out. The increase in thickness was noted. The rods were turned down by this amount, the turnings collected and analyzed for zinc and iron. Other turnings followed of varying thickness, which were also analyzed.

The results are given in the following table. The measurements are the thickness of the consecutive layers removed :

No. of rod.	No. of consecutive turning.	Meas. before galvanizing. In. dia.	Meas. after galvanizing. In. dia.	Thickness of turning.	Per cent. Fe.	Per cent. Zn.
I.	1	0·901	0·905	0·002	2·19	97·08
I.	2	0·901	....	0·0035	93·31	4·33
I.	3	0·901	....	0·002	96·04	·98
II.	1	0·901	0·905	0 002	1·87	96·42
II.	2	0·901	....	0·003	65·24	33·18
II.	3	0 901	....	0·0025	....	tr.
III.	1	0·901	0·905	0·002	1·70	97·20
III.	2	0·901	....	0·0025	62·03	33·95
III.	3	0·901	....	0 001	87·09	13·23

This table shows the increase in thickness due to galvanizing to be a ring of two one-thousandths of an inch thick, and that zinc does penetrate slightly into the iron, forming an alloy.

It will be seen that at the rate of wear indicated in the first series of experiments the coating of zinc would not last many months.

The zinc coating is not an even layer over the whole surface, but is thinner in places. This was made evident by experiment as follows: On immersing one of the galvanized rods or a piece of pipe in water, points of iron rust appeared at irregular intervals. In the water drawn from the pipe as above described some iron was always found with the zinc.

Some experiments were also made to ascertain the composition of the insoluble precipitate formed by the action of water on zinc. A quantity of chemically pure zinc was placed in a large flask and covered with filtered Cochituate water. The precipitate formed was collected from time to time, and the water was renewed and was dried over sulphuric acid. One portion contained—

ZnO	73·08
H_2O	16·90
CO_2	10·02
	99·92

Another portion dried longer gave—

ZnO	78·44
H_2O	10·98
CO_2	10·58
	100·00

This composition nearly corresponds to $5H_2O,2CO_2,8ZnO$. This zinc hydrocarbonate differs somewhat from those investigated by Rose and V. Pettenkoffer.*

At the same time as the foregoing experiments, tests were made of a pipe protected by a coating of lead, tin, and antimony (in the proportion of about 80-12-8 in the sample examined) instead of zinc. The pipe is called kalamein.

Our experiments show that the coating on our sample is not evenly laid on, the spots of iron showing as referred to in the case of the galvanized pipe. Our experiments extended over nearly a month, and the amount of lead and tin in the water drawn from the pipe was not appreciably diminished at the end of the time.

We also arranged brass pipe in the manner described for the galvanized, except that the two ends were connected so as to enable us to heat the lower part and keep up a circulation of water through the pipe, and to ascertain what metals, if any, went into solution. Zinc and copper were found in small quantities, but constantly present.

As a further evidence of chemical action the dissolved oxygen in samples of water which had remained in contact with the pipes for fifteen hours was determined by Schutzenberger's method, fully aerated Cochituate being taken as a standard and the tests being made for several days in succession.

Freshly drawn and fully aerated Cochituate gave per thousand of—

Kind of pipe.	Dissolved Oxygen.
Common iron pipe, from faucet in the laboratory, after 15 hours' contact	2·1
Brass pipe	1·6
Galvanized pipe	0·7
Kalameined pipe	0·6

—*Jour. Asso. of Engineering Societies.*

THE ARCH.†

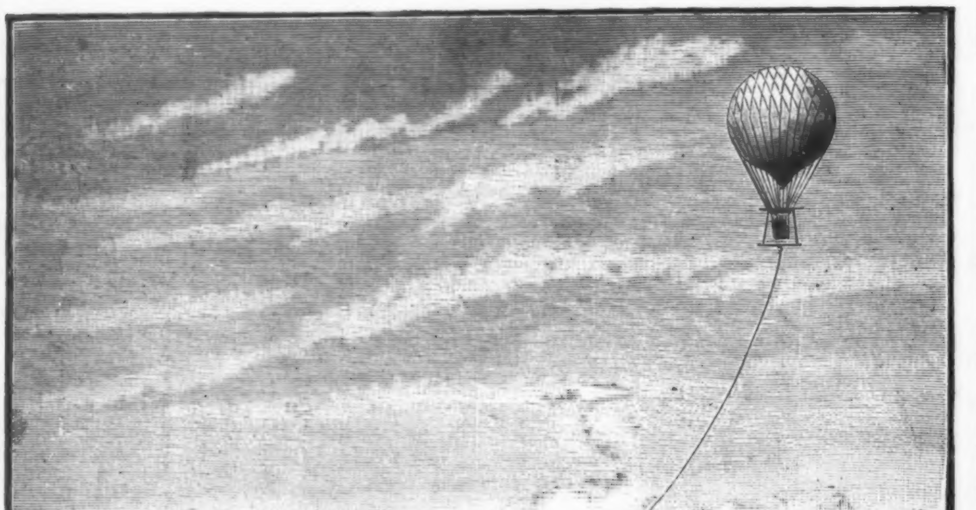
An arch, at all times, is a balanced structure which, when correctly built, maintains itself between two, more or less distant, fixed points of support, or abutments, in such a manner that all its parts shall be in perfect equilibrium, whatever the weight of the arch itself, or that of the superstructure placed upon it, may be, and however that load may be situated.

Let us consider the simplest possible form of arch, consisting of three stones only, shown in Fig. 1 opposite. Let the two abutments be, say, 6 ft. apart, and imagine that the three stones are roughly squared flagstones which, placed end to end on a floor, will cover a length of say 7½ ft. It may be conceived that if two of these stones be placed against the abutments and the third in the middle between them, as shown in the sketch, it might be possible so to place them that they would balance each other and remain as a rude self-supporting arch.

Now, though we may be unable to do this by hand, yet nature will solve the problem for us at once in this way: Let us only imagine that the stones are strong magnets and that the three stones and the abutments are turned upside down, so that the three stones shall be in suspension from the abutments, perfectly free to move at the joints, but held closely together by our supposed magnetic attraction; then the three stones would naturally fall at once into their true positions, and if we could only replace them in these exact rela-

* Rose, Pogg. Ann. 85, 107-141. Also V. Pettenkoffer, Abh. D. Tech. Commission, I., 149.

† Abstract of a paper read before the Engineering Section of the Bristol Naturalists' Society, by Mr. Charles Richardson, engineer to Severn Tunnel.



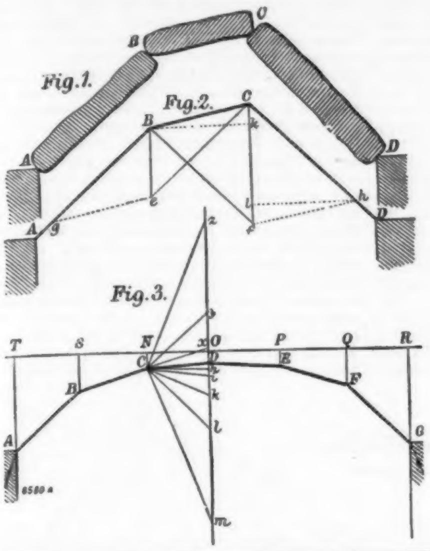
MILITARY BALLOONING—AN ASCENSION IN ABYSSINIA.

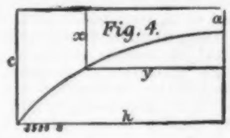
tive positions when again turned up, we should have a perfectly balanced structure.

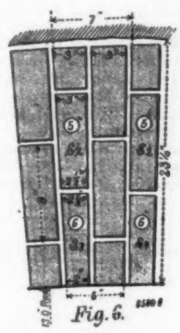
This principle of inversion and suspension is true of all balanced arch structures, whether they are of the simplest form, as in this case, or in any more complicated form, and whether they are arches of construction or inverted arches of suspension; both are dependent on the same force of gravitation combined with horizontal thrusts. All that is necessary is only that the structure should be balanced; the difference between the two forms being that the arch has to be constructed in truly balanced form, while the inverted arch falls of itself into its perfectly balanced position. The one is equipoised by art, the other by nature.

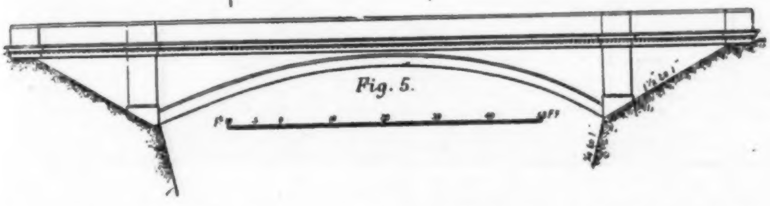
Since the arch here considered is in perfect equilibrium, the counterbalancing forces applied to the angles, B and C, in opposite directions will exactly balance each other, as may be proved by means of the well-known mechanical law of the parallelogram of forces.

For greater clearness in our diagram, we may substitute the straight lines between the points of support of the stones for the stones themselves, as has been done in Fig. 2. In this diagram, B e and C f are supposed to be vertical lines, and the other lines C e parallel to A B, $e\,g$ to B C, B f to C D, and $f\,h$ to B C.









Now in the parallelogram g B C e we have a parallelogram of forces. If the lengths of the lines g B and B C represent the opposing thrusts against the point, B, in those directions, then B e must represent the vertical load on B. Also at the point C, B C and C h represent the opposing thrusts in those directions, and C f the vertical load on C; and it is evident to the eye, from the comparative acuteness of the angle, C, that there is a greater vertical load on C than on B.

Let us draw the horizontal lines B k and $h\,l$ perpendicular to C F, then it is evident that Bk=$h\,l$, but B k is equal to the horizontal thrust of the arch at B, and $h\,l$ is equal to the horizontal thrust at C; hence the horizontal thrust throughout the arch is constant, a proposition which is true of all arches.

Having now learnt what we have from Figs. 1 and 2, which represent the simplest possible form of arch, let us proceed to learn what we can from Fig. 3. We may here suppose that we have an equilibrated arch of six rods or stones, A B, B C, C D, D E, E F, and F G, between the abutments, A and G, supporting a horizontal roadway, T R; that these rods meet at the angles B, C, D, E, and F, of which D is the central and is also the middle point in the arch; and that A T, B S, etc., are vertical lines from the respective angles up to that road line: D O being the central of these lines, and its length termed the "crown thickness" of the bridge. These lines must, of course, represent the vertical loads on each angle, if all the material between the soffit of the arch and the road line is throughout of the same specific gravity.

Now it will be recollected that in the case of Fig. 2, in order to find all the thrusts acting upon the three rods, we drew the parallelograms, B h and C g, and proved that the thrusts along A B, B C, and C D were represented respectively by the lines g B, B C, and C h, that the vertical loads on the angles B and C were represented by the verticals, B e and C f, and that the horizontal thrust in every case was represented by B k. Following the same rule of construction in the present case, but without drawing the entire parallelograms, which are not now necessary and would entirely confuse the figure, let us begin at the central point, D. First draw a vertical line, $z\,m$, through D, and C i parallel to D E, meeting z M in I. We now have a triangle of forces, C D i, in which, as proved in the former case, each side will represent the thrust in its own direction—C i the thrust along D E, D C that in its own direction, and D i the vertical load on the angle, D, which vertical load is also represented by O D, therefore D I is equal to D O, and, further, the horizontal line C h drawn from C to the line $z\,m$ will represent the horizontal thrust throughout the arch. To proceed now to the next angle, E C i is already drawn parallel to D E, let us draw C k parallel to E F, meeting $z\,m$ in k; then it follows, as before, that C k will represent the thrust along E F, and $i\,k$ (equal to P E) the vertical load on E. In the same manner draw C l parallel to F G and C m parallel to the dotted line through G, then C l and C m will represent the thrusts along F G and the dotted line through G, respectively, and $k\,l$ and $l\,m$ (equal to Q F and R G) the vertical loads on F and G. Treating the other side of arch similarly, we get the complete figure shown, and the line $z\,m$=total weight in bridge.

From what has been proved by means of this diagram, it may also be shown that if we wish to sketch an arch of the correct form to suit a given span under a given road line, we can, by an inversion of the process just described, obtain the true form of the equilibrated curve, by construction; but as the errors will be accumulative, it is better to use Dr. Hutton's formula when the arch is of large span. This formula is given in Fig. 4.

Fig. 5 is an arch with a truly equilibrated curve, the ordinates of which were obtained by the above mentioned formula.

In Fig. 5 the span of the arch is 85 ft., the rise 10½ ft., or an eighth of the span, and the crown thickness is 5½ ft. up to the road line. The road line is horizontal. The thickness of the brickwork forming the arch itself is three bricks or 27 in.; the crown thickness of 5 ft. 6 in. is therefore made up of 2 ft. 3 in. of brickwork and 3 ft. 3 in. of superstructure or metaling, etc. Being an "equilibrated" arch, the natural line of thrust passes exactly along the middle in thickness of the arch from one abutment to the other. Now, taking the weight of the material, both of the brick arch and of the superstructure, to be 1¼ cwt. or 140 lb. to the cubic foot, the load on the crown, which is 5 ft. 6 in. thick,

MOUNTAIN TRANSPORTATION—MILITARY BALLOON APPARATUS.

makes the vertical load there 7 cwt. on the square foot. The thrust or bed pressure on the brickwork at the crown is $38\frac{1}{2}$ tons on every foot in width of the arch, which is the constant horizontal thrust, throughout the whole arch; while at the springing, on account of the greater vertical load there, it will be 44·9 tons, which is the horizontal thrust multiplied by the secant of the angle of curvature at that point.

Again, taking the safe load upon the brickwork to be 5 cwt. on the square inch or 36 tons on the square foot, the necessary thickness of the arch would be $12\frac{3}{4}$ in. at the crown and 15 in. at the springing. We may therefore take 15 in. as the necessary thickness of the arch throughout, leaving a thickness of 12 in. as a margin of safety against any moving or additional load that may be placed upon it.

If a different form of curve in the arch had been adopted, that of a circular arc, for example, the thickness of the arch brickwork must contain within it the needful 15 in. of thickness all round in the true line of equilibrated thrust; for nature will follow no other, form the arch how you will. Now the circular arc leaves the true line of thrust 6 in. at the haunches on each side, therefore to make the circular arch equally strong it must be made 6 in. thicker all round. This would, therefore, require nearly a quarter more brickwork, and then the arch would not be nearly as elegant as the natural curve.

That the curve of this arch is truly equilibrated may be shown in a simple and practical manner by suspension, as has been before described.

We have here a brass chain of the length of the curve, as shown on the model drawing. Each link of the chain represents $9\frac{1}{2}$ in. of the arch, and from each link is suspended a steel rod of a length representing exactly the load upon that particular part of the arch; the model being taken to represent 1 ft. in breadth for the convenience of calculation. The model is not perfect, but it is near enough to the truth to fairly represent the various points alluded to. Let us now invert the drawing, and by means of these hooks hang on the chain, so as to bring the chain ends to the point of springing. It will be at once perceived that the chain, as it adapts itself to the true theoretical line of equilibration, precisely represents also the curve of the arch as drawn, and the ends of the suspended rods show the road line.

This is a practical proof of the accuracy of the curve calculated from the formula, and of its coincidence with the true line of thrust. But this model will tell us more than this and more than we can find out from our formula. For instance, though we may now be prepared to grant that the arch may at present be in true equilibrium as it stands, we may still wish to know how it would be affected by a very heavy load passing over the bridge from end to end. This the model will at once tell us in an equally simple and practical manner. Let us take, for example, the heaviest locomotive engine, say of 50 tons weight, on a wheel base of 16 ft., passing over the bridge; what effect will such a load have in deflecting the curve of equilibration?

First we must recollect that this wheel base of 16 ft. by 5 ft. on a permanent way would be spread, by the cohesion and friction of the structure, at an angle of at least 1:1, and that therefore the load would take a bearing on the arch below of 27 ft. long by 16 ft. wide; that is to say, that on 16 ft. in breadth of the arch a new load of 50 tons would be placed, extending 27 ft. in length. This would add $62\frac{1}{2}$ cwt. to the load on each foot in breadth of the 16 ft. Now, as we suppose the model to represent 1 ft. in breadth of the arch, then the imposition of this 50 ton engine will add a load of $62\frac{1}{2}$ cwt. to 27 ft. run of this model; and as the rods are $9\frac{1}{2}$ in. apart, it will come on 34 rods with a load of 1·84 cwt. on each rod. We have here 34 small brass weights which represent 1·84 cwt. on the scale of the model, and if we stick these weights on 34 successive rods in any part of the arch we shall see precisely the effect, on the equilibrated curve, of the 50 ton engine standing on that part of the arch.

Or, if we start from one end and stick the weights on the first 34 rods, and afterward move them forward one by one, we shall see the effect of the 50 ton engine as it passes over the whole length of the bridge. We shall find that its greatest effect is when it gets near the center, when it depresses the line of thrust $2\frac{3}{4}$ in. But as this arch has a safety margin all along of at least 12 in., our 50 ton engine, or one of 100 tons for that matter, would have no practical effect. This is very conceivable when it is known that the weight of the arch and its superstructure amounts to 8,350 tons.

In discussing the comparative strength of a brick arch, it must be premised that the arch is supposed to be built with a perfect vertical bond, and not in rings, as is too commonly and unscientifically practiced.

The vertical bond in a brick arch I have usually formed in the following manner: Referring, for example, to a tunnel arch of 13 ft. radius and $2\frac{1}{2}$ bricks in thickness, as shown in Fig. 6, two special or radial bricks are required, marked S 1 and S 2 on the sketch, in combination with ordinary bricks, which we will take to be 9 in. long, $4\frac{1}{4}$ in. broad, and 3 in. thick, with $\frac{1}{2}$ in. joints of mortar. The size of S 1 would be 9 in. long, 6 in. broad, and tapering in thickness from 2 in. at the lower end to $2\frac{1}{2}$ in. at the top; that of S 2 being 9 in. long, 5 in. broad, and tapering in thickness from $2\frac{1}{2}$ in. to 3 in. at top. These special bricks would be of the same cubical contents as the ordinary bricks, and could be made in large quantities for 4s. a thousand extra.

Referring once more to the sketch, it may be observed how the bricks are laid forming a full half brick vertical bond, the mixture of common and special bricks shown in two courses of the sketch making together one block of the brickwork exactly fitting the curvature of the arch, six common bricks being used to every four specials; and as a thousand bricks will make three yards of brickwork, the additional cost would only be 6d. a yard over the whole arch. The fact of the special bricks being made of a different breadth from the ordinary bricks is useful in order to break the horizontal joints, and it besides enables the men readily to distinguish them; they call them the 5 in. and 6 in. bricks, and cannot make any mistake in using them. But in flat arches, like that shown in the model, special bricks are not wanted in order to form the vertical bond, for the tapering of each course can then be formed in the cement. In the model bridge, for example, the tapering on the whole thickness of the arch, 27 in., amounts to no more than $\frac{1}{8}$ in., which may be managed by making the joint $\frac{1}{16}$ in. closer on the centering and the same amount wider at the back. In actual practice I have never found that special bricks are needed in an arch which has a curvature of 30 ft. or more in radius.

Before leaving the subject of brick arches it will be as well to say a few words as to arches built in rings of brickwork. This system, which has been so common in this country, though not now used abroad, has been adopted no doubt in order to make use of nothing but common bricks. In a ring-built arch each ring is a separate $4\frac{1}{2}$ in. arch, and the entire arch is made up of so many distinct $4\frac{1}{2}$ in. arches built one over the other. This is practically proved the moment there is any settlement in the arch or its abutments; the rings part company immediately, and nothing but friction keeps the arch up—the real arch principle is gone. Then again, when the curve of the arch varies at all from the equilibrated curve explained above, if the natural line of thrust passes from one ring into the next, the arch would fall at once if friction did not prevent it. In arches of small span it does not so much matter, but in arches of large span it is fatal. Arches of wide span cannot be built with safety in rings; for example, referring to the model, the natural line of thrust must then pass round through each single $4\frac{1}{2}$ in. arch; but if that arch were built in the form of a circular arc, the line of thrust would, as has been stated, leave the ring courses for a distance of 6 in., and the line of thrust would pass from one $4\frac{1}{2}$ in. arch into its neighbor; and under the great thrust due to a wide span, the rings would slide upon one another, the haunches would rise, and the crown would droop until the arch fell. Even if built upon the true equilibrated curve its stability would be very precarious, so slight a margin being left for any little settlement or other accidental defect.

The almost universal adoption of the ring system of building arches, together with the use of unscientific curvature in the form of the arch, with the consequent settlement or failure of many of them, may probably account for the timidity of engineers in adopting brick arches of wide span.

A semicircular arch under a horizontal roadway is always wrong; the natural line of thrust must always pass out of the arch into the backing, and if the arch stands, it is by friction only and by the good quality of the backing, which has to sustain the heaviest part of the thrust.

A NEW METHOD OF STOCKING AND RELOADING COAL.*

THE conveyors employed for this work are of two varieties: The first, called the flying extension, consists of an endless chain, to which are attached flights or scrapers, forming a chain conveyor, at the lower end of which is a sprocket wheel, situated under the railroad track, and the other end passing around a traction wheel secured at the upper end of a pole, which is held in an upright position by suitable guys. (Figs. 1 and 2.) The conveyors of this kind which are now in use are about one hundred and fifty feet long, with the upper end located from fifty to seventy-five feet above the ground. The scrapers are 8"×20" in size, and are placed at intervals of two feet on the conveyor chain. There is no support for the lower strand of chain between the foot and head wheels. The upper strand is supported on idler wheels at intervals of fifty feet. These wheels are either suspended on wire cables or supported by light trestle work, if convenient. The province of the flying extension is to take coal from the dump situated above the lower end, and convey it toward its head wheel, thus forming a pile of coal, the general shape of which is conical, with the apex under the lower strand of chain, and if the conveyor is fed until it has conveyed coal to its upper end, the apex will be directly under the head wheel, forming a pile, say sixty-five feet high and three hundred feet across its base, and containing about twenty thousand tons. The pile of coal so formed is in the best possible condition to be reloaded, as there is no trestle work or other timber obstruction, excepting the pole, in it. In the event of it being advisable to use the same apparatus at another place after its having built one pile, the only portion remaining in the pile would be the pole, the value of which would be about fifteen dollars. The apparatus described has a capacity of about two tons per minute, and this could be increased almost indefinitely, if required. It is difficult to make a comparison between the cost of stocking coal by this method and the ordinary plan of using hand labor after the space under the trestle has been filled up, because it is practically impossible to make such immense piles of coal by hand. The average cost, however, of stocking coal on either side of a trestle to a distance of say twenty feet is about thirty cents a ton, whereas the cost for stocking coal with the flying extension is but a fraction of this amount. There are four of these conveyors now in use at the wharves of the Philadelphia and Reading Railroad Company at Port Richmond, Philadelphia, and others in process of erection. For reloading the coal into cars after it has been stocked, a conveyor is used which is so constructed that it may be moved sideways toward the base of the pile, and kept running continuously while it automatically attacks and conveys the coal toward the trestle from which it was originally dumped, at which point it discharges the coal into an inclined conveyor which elevates it into a loading pocket, from which it is tapped into cars. The reloading conveyor is so constructed that it can be swung to the right or left, and is capable of operating on either side. Consequently, by locating it between two flying extensions, it would be able to reload the coal stocked by either of them. By means of the flying extension and reloading conveyors, it is possible to store immense quantities of coal on vacant land at some distance from the sea coast, and cheaply reload it and deliver it at tide water as called for, instead of storing coal under expensive trestle work and upon valuable dock property.

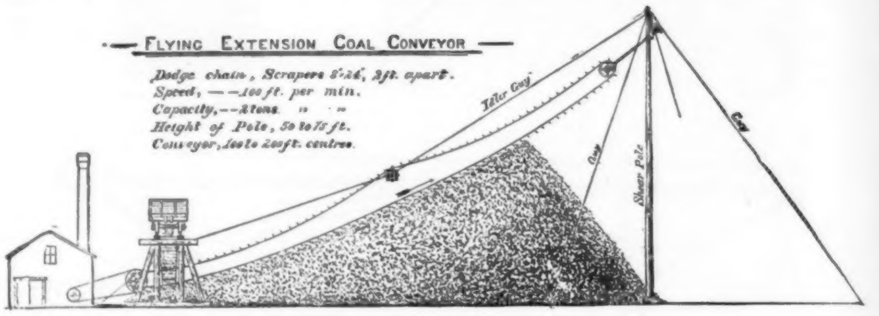


FIG. 1.

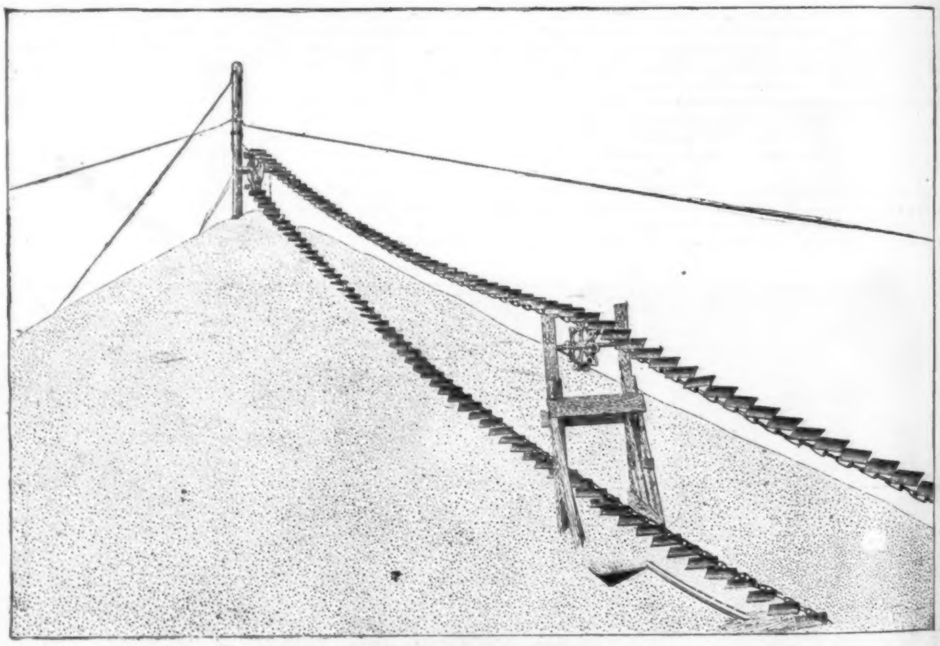


FIG. 2.

STOCKING AND RELOADING COAL.

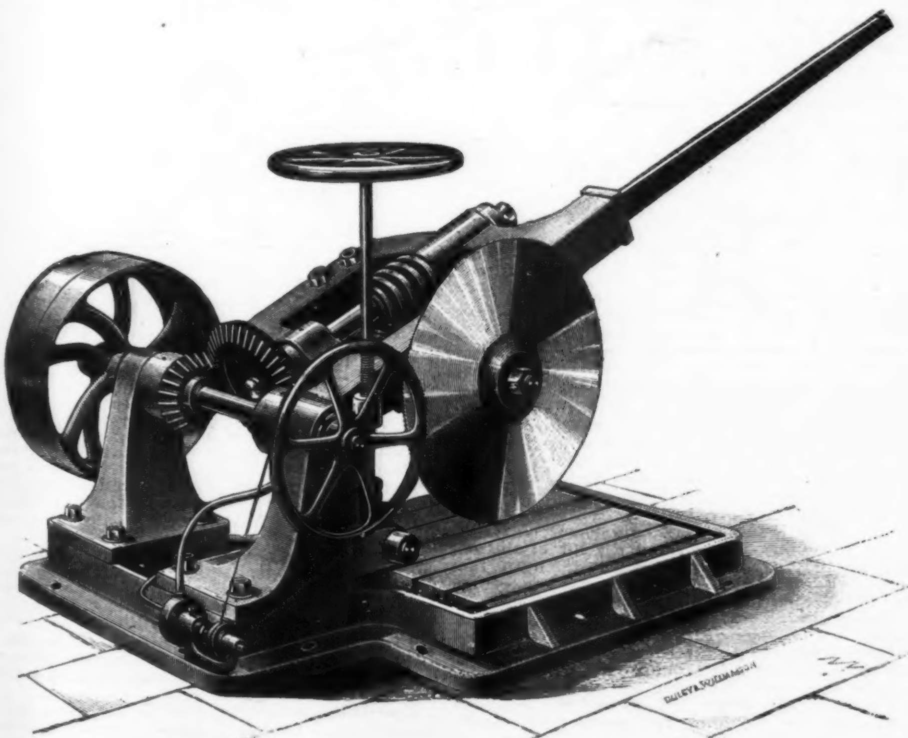
* A paper presented before the sixteenth meeting of the American Society of Mechanical Engineers, at Philadelphia, November, 1887. By James M. Dodge, Philadelphia, Pa., member of the society.—*American Engineer.*

THE "HETHERINGTON" SAW.

OUR illustration represents an improved machine for sawing iron or steel bars of various sections while cold, constructed by Hetherington & Co., engineers, Manchester. This machine is fitted with a saw 22 in. diam., and it will cut round or square bars up to 5 in. and channel sections up to 12 in. by 6 in. As will be seen, it is constructed with a planed bed plate, in which are T slots for bolting down the work, and surrounding this is a trough into which flows the soap and water used for lubricating. The saw itself is fastened to a steel spindle carried in two bearings, which are attached to the two sides of an oscillating frame. To the saw spindle is fastened between the bearings a gun metal worm wheel, into which gears a steel worm cut out of the solid and forming part of the spindle carried by bearings arranged longitudinally in the frame. The power is transmitted by means of a belt working upon fast and loose pulleys, which are carried on a cross shaft supported by two curved standards bolted to the bed plate. By means of bevel wheels, clearly shown in the illustration, the motion of the cross shaft is communicated to the worm. The inner bosses of the standards are turned so as to form trunnions, on which the saw frame is pivoted. The feed motion is effected by means of a hand lever, to which, if desired, a weight can be attached; but on commencing, the frame is lowered by the vertical screwed spindle, on the end of which is a hand wheel.

When the saw comes in contact with the work, this screw is run back sufficiently to free the frame, lock nuts being arranged to act as a stop when the saw has gone through the bar or channel section. The saw is thus prevented from cutting through the bed plate, and its range of movement limited. The lubricant is supplied by a small centrifugal pump driven from a grooved pulley on the end of the driving shaft, so that while the saw is running a plentiful and continuous stream is thrown upon it. When it is necessary to sharpen the saw, a small emery wheel can be attached so as to treat each tooth, being driven from a groove formed on the outer edge of the loose pulley, while the saw is held by a pawl, which enables it to be moved forward a tooth at a time. It will be seen that the machine is very complete, and that provision has been made for all contingencies. All the bearings are long, and ample strength is given to every part of the machine. We understand that the makers have now a large number of these machines in use under all conditions of work, and that, as the cost is reasonable, it is taking the place of other machines designed for the same class of work.

It will be seen that the rate of traverse of the saw is variable, being greater where a small amount of metal has to be cut and slower where a large area is being treated. It is claimed that in this way the saws are able to maintain a higher average speed with less damage than in the older style of machine. The circumferential velocity recommended by the makers for cutting iron or steel is 50 ft. per minute, and at this speed a girder of H section 12 in. by 6 in., with a thickness of $\frac{11}{16}$ in., may be cut in ten minutes; a similar section, but only 9½ in. by 3½ in., and $\frac{7}{16}$ in. thick, occupying only four minutes to cut.—*Industries.*

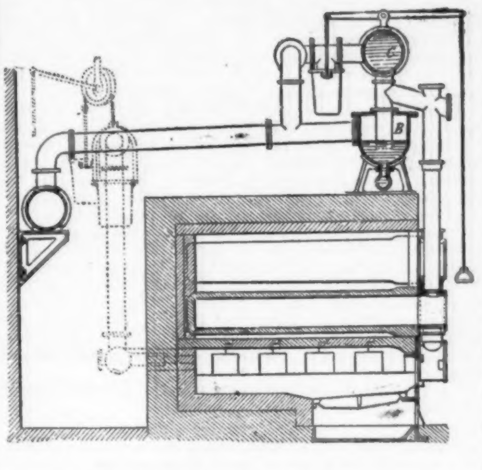


THE "HETHERINGTON" SAW.

LARGERON'S ANTI-DIP ARRANGEMENT.

NOTWITHSTANDING the existence of something like fifty different devices for suppressing the dip in the hydraulic main, our readers will see, by the accompanying engraving, that ingenuity in the production of others has not been exhausted. The appliance shown is the invention of Mons. F. Largeron, manager of the gas works at Firminy, in the department of the Loire; and for the illustration and the following particulars in reference to it we are indebted, says the *Gas Light Journal*, to the last number of *Le Gaz*.

In the application of M. Largeron's system, the hydraulic main, B, is divided off in sections corresponding to the width of each setting of retorts. Above the hydraulic main proper is a second or auxiliary main, C, of similar length, communicating with the upper ends of the dip pipes by means of a number of tubulures equal in size to the dips. Consequently, when the lower ends of the latter are sealed to a suitable depth in the liquid in the hydraulic main, B, the gas coming from the retorts necessarily encounters an obstacle to its passage in that direction, and therefore at once rises freely into the auxiliary main. This goes on through the entire period of distillation. During this time the gas passes from the auxiliary main into the principal collector, by means of a pipe which is branched to the



lower as well as to the upper main. The valve interposed upon the upper branch of this pipe is open, and consequently allows the gas to have free passage. The lower branch of the pipe maintains the liquid at an invariable level, by allowing any excess to flow into the well.

At the end of the charge the valve is shut, and consequently the passage of the gas is completely intercepted—by the closed valve on the one hand and by the sealed ends of the dip pipes on the other. In this way each retort is isolated, and may be opened without the least inconvenience. As the retorts are recharged, the gas forces its way beneath the ends of the dip pipes, and bubbles through the liquid in the hydraulic main in the ordinary way. As soon, however, as the last retort in the setting is charged, the valve is again opened, when the free passage of the gas by the branch pipe from the auxiliary main will be restored, and the retorts relieved of pressure during the time the charge is being worked off.

Our contemporary considers the arrangement thoroughly simple and practicable. The auxiliary hydraulic main (being placed above the ordinary main) has this advantage, that to a certain extent the process of hot condensation is initiated under conditions which are very favorable to the immediate separation of the gas and tar; for the condensed liquid redescends, through the dip pipes, directly into the hydraulic main, with the result that the gas does not remain in contact with it. In this respect, therefore, the superposition of the auxiliary hydraulic main over the ordinary one appears to be calculated to produce satisfactory results. The operation of interrupting and restoring the flow of the gas as desired is very simple. The valve shown in the illustration is of the hydraulic type, and is opened and closed by simply lowering and raising a cast iron cup. It may be worked in various ways, and from any distance. The rod and lever arrangement shown in the illustration may be replaced by a chain and guide pulley. It will be noticed that under the hydraulic main, and connected with it by a short piece of pipe, there is another pipe, by which, with the aid of a suitably disposed siphon, the heavier parts of the tar are removed, so as to prevent any thickening of this substance in the bottom of the main.

The arrangements above described constitute M. Largeron's system in its entirety. Reference may, however, be made to an accessory appliance, the object of which is to fractionate the gas produced, and to collect separately the portion coming off during the latter part of the charge, which, as is well known, is generally of low illuminating power. This gas may be employed for motive power, or even for heating the furnaces. The arrangement to facilitate its latter application is shown by the figure represented by dotted lines in the illustration. This fractionation necessitates the attachment of a supplementary pipe and two valves, one of which is inserted in the first pipe and the other in the second, which enters the back of the furnace. It may be easily perceived that if by means of a rocking motion the valve on the first pipe is closed while the other is opened, the gas will immediately cease to pass into the collecting main, and flow into the pipe entering the back of the furnace. The arrangement thus briefly described might be usefully employed in cases where managers have such a liberal production of gas as to allow of their utilizing for other than lighting purposes the less luminiferous portions coming off toward the end of the charge.

The main feature of the Largeron arrangement, taking it as a whole, is the adoption of the auxiliary hydraulic main, placed as shown, and the bifurcation of the outlet pipe for the gas, whereby, as already explained, the suppression of the dip may be effected during carbonization. In works where no exhausters are employed, and where the manufacturing operations are not on a sufficiently large scale to necessitate their erection, the Largeron system could, it would seem, be usefully employed. Even where exhausters are in use, however, it might be advantageously adopted, since by its use the pressure of the dips is obviated, and the numerous inconveniences occasioned by this pressure during the progress of carbonization are effectually remedied.

FUEL GAS AND INCANDESCENT GAS LIGHTING.

CHAS. M. LUNGREN, C.E.

ECONOMY OF INCANDESCENT GAS LIGHTING.

THE question whether gas companies should undertake to supply electric lighting or not is one which mainly turns upon the possibilities of fuel gas and incandescent gas lighting. If it shall appear that with one set of distributive apparatus, gas companies can respond to the growing demand for gaseous fuel, and at the same time furnish through the medium of fuel gas a light superior to that now given, it would seem that there would remain but little inducement to supply electricity. If it should further appear that incandescent gas lights operated by fuel gas will prove to be the cheapest of all artificial illuminants, the inducement would wholly disappear. To reach the conclusion that the future of the gas industry lies in the direction of fuel gas and incandescent gas lighting, it must of course be shown beyond peradventure that a fuel gas can be made and distributed at a price that will enable the consumer to use it for fuel purposes, and that will offer a sufficient return to the gas maker, and, further, that the incandescent gas light is a practical apparatus for the purpose. It is, perhaps, too early to answer these questions decisively in the affirmative, but those who have studied the questions involved the most closely, and who have had the most experience in the experimental work relating to the subject, have the greatest confidence that they will be so answered.

Mr. McMillin, in his recent able paper, has called renewed attention to the subject of fuel gas, and has set many people thinking about it in a serious way, as a probable present realization, rather than a hope for something at a future time.

The subject is now in a fair way of receiving the careful attention, not alone of technologists, but of those who will be prepared to demonstrate the practicability of a manufactured fuel gas on a commercial scale, and it may reasonably be expected that, in the course of a few years, many of the questions which now are speculative will be definitely settled by the test of experience. The incandescent gas lamp has yet to prove its utility, and its ability to meet the manifold requirements for artificial light, but it may be confidently asserted that it will be able to do this. Doubtless there will be difficulties to surmount, but that these will be overcome, and that there will be evolved a thoroughly practical apparatus, I, for one, am fully persuaded.

Just how practicable a system of fuel gas and incandescent gas lighting will prove to be as a commercial undertaking, can, of course, be determined only by experience. But from the data available, it will, perhaps, be possible to form a tolerably correct estimate of the conditions with which the system will have to comply, and the character and extent of the market which it may make for itself and securely hold against all comers. I propose, therefore, in these papers to consider what will be required for fuel gas by the consumer from an economic point of view, and how fully the gas maker will be able to meet these requirements.

Preliminary to the discussion of fuel gas itself, it has seemed to me desirable to inquire how the incandescent fuel gas light will compare with other forms of artificial lighting, both in the matter of expenditure of energy per unit of light and in its cost to the consumer, with a view of determining its economic place, and hence its desirability as an illuminant.

I shall confine the comparison to the results obtainable with fuel gas, as it is a matter of very little moment what results are obtained with a mixture of illuminating gas and air, first, because the significance of the incandescent gas light lies wholly in its value in making the universal distribution of fuel gas economically practicable; and, second, because it would be useless to distribute a high cost gas, even if the object was simply to furnish light, when a gas at low cost would do equally well. I shall assume, for the purpose of this comparison, a fuel gas having a heating

value of 8,000 heat units and a specific gravity which will give 24' to the pound. I shall assume, further, that the incandescent lamp yields four candles to the foot.

This gas will be an uncarbureted water gas, and if well made will have about the above heating capacity. The candle power assumed for the incandescent lamp is one that can without great difficulty be reached, and will very possibly be surpassed in practice. On the basis of these figures, 1' of the gas will have a heating power of 336 heat units; at four candles to the foot, this will represent a heat expenditure per candle of $\frac{336}{4}$=84 heat units. At fifty cents per 1,000' the cost to the consumer of a twenty candle light, exclusive of that of the renewal of the incandescing material, will be one-fourth of a cent an hour; or to state it somewhat differently, the consumer will get eighty candles distributed in four centers for one cent an hour. The renewal of the incandescent material will not exceed fifty cents for 1,000 hours, which is ordinarily a year's burning. The maximum price at which a fuel gas of this heating power can be sold cannot well be more than fifty cents per 1,000'. Once established, the large demand will in all probability enable the price to be lowered. Taking twenty-five cents per 1,000' as the lower limit, the consumer would then get 160 candles distributed in eight centers for one cent an hour. If in this the cost of renewing the incandescent material at fifty cents for 1,000 hours' burning is included, there would be obtained in the first case sixty-six and two-thirds candles for one cent an hour, and in the second 133⅓ candles for the same amount.

Comparing this with the incandescent electric lamp, it will be found that, both in the matter of cost and the expenditure of energy, the gas incandescent is superior. The energy expended in a filament of an incandescent electric lamp, to produce any given amount of light, is accurately determinable. It is the product of the current by the electrical pressure, or the square of the current by the resistance of the filament. According to the tests of the commission of the Paris Electrical Exhibition, in 1881, the expenditure of energy in the filament of an Edison sixteen candle lamp is 60·16 watts, or a trifle over 0·08 English horse power. This is equal to 158,400 foot pounds or 205 heat units per hour. The expenditure per candle per hour is therefore $\frac{205}{16}$ = 12·8 heat units. The incandescent electric lamp is therefore an extremely efficient instrument for converting heat into light. How it compares with the incandescent gas light in this respect, we have no means of knowing, as we cannot well determine just how much of the heat supplied in the latter case is utilized in the production of light. In order, however, to get this expenditure of 12·8 heat units per candle to the filament, it is necessary to make a very much larger heat expenditure. The highest result claimed by any of the incandescent electric light manufacturers is, I believe, ten lamps of sixteen candles each maintained in the system for each actual horse power applied to the dynamo. Allowing that this can be done, then there is used three pounds of coal per horse power, and, if the coal has a theoretic heating value of 13,000 heat units per pound, it appears that, in order to expend 12·8 heat units in the filament per candle, there must be expended at the generating dynamos $\frac{39000}{160}$ = 243·75 heat units.

If illuminating gas be substituted for the coal, there will be required 25' per hour to produce an actual horse power. Ordinary coal gas will have a heating capacity of 650 heat units per foot. The expenditure will therefore be 650 × 25 = 16,250 heat units for 160 candles, or $\frac{16250}{160}$ = 101 50 heat units per candle per hour. Operated with any kind of fuel gas, the heat expenditure will be the same. It thus appears that the expenditure of energy in the two kinds of illuminants above considered stands in the relation of 84 to 101 on the best showing of electricity, and as 84 to 243 when coal is used. In the matter of cost, with fuel gas at fifty cents per 1,000', the consumer must get five sixteen candle lamps for one cent; and with fuel gas at twenty-five cents per 1,000', he must get ten. Is there any possibility of electricity ever approaching these figures? Could it even be done with fuel furnished free? In comparing these two forms of light, it is not necessary to take into account the renewal of the incandescent material, as the expense of this, in the case of the electric light, would be, if anything, greater than that for incandescent gas lighting.

In comparing the incandescent gas light with illuminating gas burned in ordinary batwing burners, average coal gas may be taken as having a heating power of 650 heat units per foot, and as giving eighteen candles for 5' consumption per hour. This heating value is somewhat below that given by Mr. McMillin, but it is probably not far from the average gas. The candle power is probably somewhat high for a gas of this heat value, but I prefer in such comparison to over rather than under value it, and will therefore let it stand. The heat expenditure per candle is therefore 650 ÷ 3 6 = 180 heat units. To be as cheap as the incandescent light with fuel gas at fifty cents per 1,000' it must furnish sixty-six and two-thirds candles for one cent. This will require 18½', which is at the rate of fifty-four cents per 1,000'. An illuminating water gas of a candle power one-third greater would have a heat value of about twenty-five per cent. greater, and would therefore make a somewhat better showing. The comparison in this case is properly made between the cost of the incandescent light, including that of the incandescent material, and the cost of the illuminating gas alone, as there is no further cost in the latter case.

If the gas be burned regeneratively, double the candle power per foot may possibly be obtained. Considerably higher results than this have been claimed, but those who have had most experience in regenerative gas lighting on its experimental side know that it is very questionable whether even this could be maintained in practice in a lamp small enough to be suitable for a chandelier. Further, the increased trouble and the greater amount of radiant heat from such lamps would very largely preclude their use on chandeliers. In large lamps hung high and provided with efficient governors, the troubles that would appear in the small ones are not experienced. Taking then the even figures of nine candles to the foot as the best result to be expected from eighteen candle gas, the regenerative lamp would require an expenditure per candle of $\frac{840}{9}$ = 93 heat units. To be as economical as the incandescent, the gas must be sold at eighty-seven cents when fuel gas is fifty cents per 1,000'. The comparison here is directly on the basis of the light furnished, as the cost of glasses and renewal of parts of lamp would very probably equal the cost of the incandescent material.

There remains to be considered the kerosene lamp. Largely as this apparatus is in use, there appear to be no reliable data upon relation to candle power to consumption. With the appearance of the high power kerosene burners of recent years, there has been developed a recklessness of statement as to candle power which finds place in no other field of artificial lighting, with the possible exception of that of the arc electric light. As near as can be ascertained, the best forms of kerosene burner will give a light of thirty candles with a consumption of a quart of oil in eight hours. This gives 960 candles per gallon. I have not been able to obtain any exact data on the heating power of ordinary lamp kerosene, but placing it at 25,000 heat units to the pound and seven pounds to the gallon, the expenditure per candle is $\frac{175000}{960}$ = 182 heat units.

At fifteen cents per gallon, there is obtained $\frac{960}{15}$ = 64 candles for one cent. At twelve cents per gallon, which I believe is the lowest price at which a safe lamp oil can be bought, the result is eighty candles for the same amount. In a comparison between kerosene and the incandescent gas light, the cost of the incandescent may be neglected, as this will be amply offset by that of chimneys and wicks. It thus appears that at the price at which kerosene is ordinarily bought by the householder, the incandescent gas light is superior in economy, while it is equal to it at the minimum price at which kerosene can be obtained. But this is at the maximum price of fuel gas; that is, fifty cents per 1,000'. At twenty-five cents per 1 000', the incandescent easily distances the cheapest of all present illuminants.

Tabulating the results obtained, the account stands as follows:

EXPENDITURE OF ENERGY PER HOUR FOR PRODUCTION OF ONE CANDLE OF LIGHT.

Light.	Heat units per candle.		Heat units per foot.	Heat units per pound.
Inc. gas	84		336	8,000
Inc. elec	243	(coal as fuel)	...	....
Inc. elec	101	(gas as fuel)	...	....
Coal gas	180	18 candle, Batwing burner,	650	22,750
Coal gas	93	18 candle, Regenerative lamp,		
Kerosene	182		...	25,000

COST TO THE CONSUMER.

Light.	Candles for 1 cent an hour.		Price per 1,000 candles.	Price per 1,000'.	Price per gallon.
Inc. gas	80	(without inc.)	....	50c.	....
Inc. gas	66⅔	(with inc.)			
Inc. gas	160	(without inc.)	....	25c.	....
Inc. gas	133	(with inc.)			
Inc. elec	80		10½c.	....	....
Inc. elec	160		5¼c.	....	....
Coal gas	66⅔	18 candle, Batwing burner,	....	54c.	....
Coal gas	133	18 candle, Batwing burner,	....	27c.	....
Coal gas	80	18 candle, Reg. lamp,	....	87c.	....
Coal gas	160	18 candle, Reg. lamp,	....	43½c.	....
Kerosene	64		....	....	15c.
Kerosene	80		....	....	12c.

It appears from these figures that at the maximum price at which a fuel gas of the assumed heat value can be sold, an incandescent gas light, fulfilling the two requirements of four candles to the foot, and a cost of fifty cents a year for the incandescing material, would be as cheap as kerosene at the lowest figure, while any gain in the stipulated candle power or decrease in the price of the gas would give it the position of the cheapest of all artificial lights. It should be borne in mind that the possibility of furnishing a light at this extremely low cost is directly dependent upon the fuel feature of the distributed gas. A fuel gas can be furnished to the consumer at fifty cents per 1,000' not simply because its first cost is low, but because it can be furnished in enormous quantities. It is questionable whether any gas can be furnished for lighting alone at this price, and pay a fair commercial return, even if the gas in the holder is without cost to the company. Gas companies furnishing fuel gas and the incandescent gas light are providing two prime desiderata in the household—light and heat. The competency of any competing system must be judged by its ability to furnish something for which there is an equally large and continuous demand. An electric system can only furnish light and power, and by no conceivable extension of the demand for power can it become equal to that for heat in the household, which is the great center of consumption. Any system, therefore, which is able through the medium of one set of distributive apparatus to furnish light and heat has an economical advantage over any system which can furnish light and any other one thing whatsoever. So long as the conditions of existence remain even approximately as they are at present, the demand for light and heat will continue to be a primal one, and those who minister to it may rest assured that, whatever the surprises of the future, they have nothing to fear.—*Light, Heat and Power.*

A MULTIPLE MAGNESIUM LIGHT.

MAGNESIUM burnt in oxygen emits a much more actinic light than if burnt in ordinary air. Assuming it to be impossible to get a satisfactory negative from a single light, and also taking into consideration that the amount of actinism emitted by a given quantity of magnesium varies according to the amount of oxygen present in immediate contact at the moment of combustion, I thought that if a number of lights could be ignited simultaneously, and the magnesium used in those lights could be burned in pure oxygen, the weak points of the McLellan light would be overcome; and on setting to work in the latter end of the autumn of 1886, I constructed the apparatus to which my friend Mr. Carter refers.

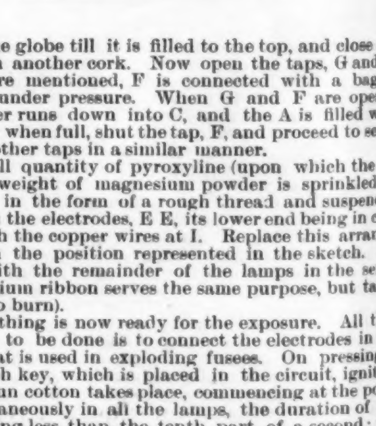
This apparatus was shown more than a year ago to a number of my friends in the photographic way. Also advertisements appeared in the local papers stating that photos would be taken in private houses, etc., by means of its light.

When present at the photographic convention in Glasgow, in July last, I described it to Mr. Carter and some of my friends there. The apparatus consists of a series of lamps, one of which is represented in the subjoined sketch.

The lamp is composed of a glass vessel, A. (The chimney of an ordinary duplex lamp answers well, but where large quantities of pyroxyline are exploded, it is safer to use steam gauge tubes.) The lower end of this globe is cemented by means of a shellac into a metal tube, B, which terminates in the vessel, C. C is capable of containing at least three times the cubic contents of A. On the top of the chimney is cemented a metal ring, into which the cork, D (carrying the brass or copper rods, E E), fits tightly. These rods have binding screws at the top and bottom. From the top wires lead to an induction coil. At the bottom are placed and fixed, by means of the binding screws, two small pieces of copper wire, with their points in contact at I. The points which meet at I must have been previously tipped with a mixture of equal parts of subphosphide of copper and the material of which the heads of matches are composed. Soak the heads off a lot, and it will save the trouble of making the compound. When this composition is dry on the copper wires, they are ready for use.

The tap, F, communicates with a bag of oxygen. Tap G (which is of large diameter) allows free ingress and egress of air, as will be explained further on. H is an ordinary gas jet, which is used for the purpose of focusing.

To use the apparatus: Commence by suspending as many lamps as may be required, connect the gas jets by India rubber tubes. All the oxygen taps are connected in a similar manner. Turn on the gas and proceed to arrange the lamps in such positions as will light the sitter to your satisfaction. When this is accomplished, see that all the other stop cocks are shut. Remove the cork carrying the brass rods, and pour water in the globe till it is filled to the top, and close the top with another cork. Now open the taps, G and F. As before mentioned, F is connected with a bag of oxygen under pressure. When G and F are opened the water runs down into C, and the A is filled with oxygen; when full, shut the tap, F, and proceed to serve all the other taps in a similar manner.



A small quantity of pyroxyline (upon which the required weight of magnesium powder is sprinkled) is twisted in the form of a rough thread and suspended between the electrodes, E E, its lower end being in contact with the copper wires at I. Replace this arrangement in the position represented in the sketch. Do ditto with the remainder of the lamps in the series (magnesium ribbon serves the same purpose, but takes longer to burn).

Everything is now ready for the exposure. All that remains to be done is to connect the electrodes in the form that is used in exploding fusees. On pressing a telegraph key, which is placed in the circuit, ignition of the gun cotton takes place, commencing at the point I simultaneously in all the lamps, the duration of the flash being less than the tenth part of a second; the water in C immediately rushes up to take the place of the O used in the combustion of the magnesium.

On opening F, the O once more bubbles up through the water till the latter recedes, carrying with it nearly all the magnesium oxide into the vessel, C, and the apparatus is now ready for preparation of another exposure.

The water serves the double purpose of washing down the MgO and preventing its escape into the air, and of taking the place of the oxygen, which has united with the Mg, thus preventing the dilution of the O with ordinary air. The advantages of an apparatus of this description are apparent; no fumes escape through the studio. If the same quantity of magnesium be used, the negative is always correctly exposed, other things being equal. Pictures equal to those taken in daylight may be obtained by means of it if the operator has sufficient skill to arrange the gas jets before exposure.

Translucent screens should be used between the sitter and the source of light.—*P. Swanson, in Photographic News.*

AMERICAN MILL METHODS—A POPULAR DESCRIPTION OF HOW FLOUR IS MADE AT THE PRESENT TIME.

By LOUIS H. GIBSON.

WOMAN was probably the first miller. It was the woman of the primitive people who did most of the manual labor. The first miller was not a specialist. She did not pose as a miller, but as she sat mashing the grain on a rock, she probably had a baby or two in her arms, and three or four trotting around her. She told them to keep their fingers away or they would get them pounded, just as little boys and girls who run around the mills in these days are warned against getting caught in the machinery. The primitive mill had its catastrophes in the shape of mashed fingers. The serious character of the accidents of to-day are in keeping with the progress of the art. It took a great mill, a large and complicated establishment, to explode and kill a large number of people and destroy many thousands of dollars' worth of property.

The physical examination of wheat shows the grains or berries to be of different qualities, varying from each other only slightly in form, which is generally an irregularly oblong oval, having a deep groove extending from end to end, which gives to a cross section a surface bounded by three right angles. At one end of the berry is the brush, or vegetable hairs. At the opposite extreme, under an irregularly curved surface layer of bran, technically called the shield, is the embryo or germ.

If a blade of a sharp knife be passed through the wheat berry midway between the two ends, there will be presented a section which, under the microscope, will show an exterior envelope of several layers, an interior envelope consisting of cells and their contents of gluten and phosphate, constituting the most nutritious portion of the berry, and a mass of white, consisting of loose cellular tissue, supporting a vast body of starch granules, clusters of cells of albuminoid matter extending to the heart of the berry. If a grain of wheat be moistened with water and rubbed between the folds of a rough cloth, the outer covering may be readily detached. This is composed of two layers. The inner coat of the bran proper is made of transverse tubes which, from their arrangement side by side, suggest the convenient name of cigar coat. The third is the seed skin. In it are the granules which make the coloring matter, which determine whether the wheat is red or yellow, or, by their absence, leave it white. In the inner membrane, the comb coat, are set the gluten sacs, containing the cells affording the gluten and phosphates. It is necessary to go through this tiresome description in order to make the subsequent matter clearer.

Before considering the reduction of the wheat, I will say something about the way in which it is cleaned. The process consists in the removal of all foreign material from the mass of grain and the fibrous and fuzzy exterior from the grain itself. The foreign impurities consist of dust, sand, chaff, straw, etc. There are numerous seeds, chit, wild onions, corn and other foreign grains and seeds. Then there are the blasted kernels of wheat, rust, and ergot (smut). In some parts of the country there is trouble from small bits of clay getting mixed with the wheat, and there are always pieces of metal, such as nails, screws, wire, etc. The cleaning of the wheat involves the removal of all these foreign impurities, and as well the removal of the attached impurities so far as that is possible. In order to make a separation of any kind, there must be a distinction as to form, size, specific gravity, general structure, or magnetic affinity. The wheat in passing over a screen passes through openings which are adapted to its form.

These screens are made of zinc in light sheets, and are perforated in forms consistent with the various separations which they are to make. They are attached to sieve frames. By means of these screens, chaff, straw, oats and particles of sticks are separated from the wheat by taking advantage of the elongated form of these impurities.

The wheat passes through the screen openings, which are abundantly large for their passage, but as the screen is inclined, each berry must be tipped in order to enter the hole. Each hole in the screen which makes these separations is of such diameter that when the wheat grain, sliding forward, carries its center of gravity beyond the support of the upper edge of the hole, it drops through. The oats, grain, and other similarly formed substances, being longer than the wheat grain, will for this reason extend over the lower margin of the hole before the weight of the lower end is sufficient to cause it to dip and fall through. Thus it passes over the end of the screen and goes off as impurities.

The separation as to cockle and other round seeds is made in another way. One device is a cylinder of partially perforated or indentated metal. The cylinder is kept in slow revolution. Within this cylinder is a trough which is given a slow, shaking motion and is inclined at an angle of about ten degrees. The indentations in the outer cylinder are of such a depth as to allow the small seeds to rest in them until the cylinder has revolved sufficiently to allow the small seeds to fall back, not into the cylinder itself, but into the vibrating trough within, the movement and slant of which is sufficient to conduct these impurities into a separate spout. The form of the wheat berry does not allow it to become embedded in the perforations or indentations of the cylinder sufficiently to carry it so as to fall into the trough.

Separations as to the size of the impurities are made by passing the grain over perforated screens, which allow the impurities which are larger than the wheat to pass over the screen, and the wheat to pass through the openings. From thence the wheat passes to other screens which are smaller than the wheat itself, and through which the smaller impurities pass. Thus exact separations are made.

Another condition to be taken advantage of in cleaning wheat is the variation in specific gravity, which is the ratio of weight of bodies of equal volume to one another, when taken in connection with a standard. Bits of chaff, straw, and dust are of less specific gravity than wheat. That is, the same volume of such articles weighs less than the wheat grains themselves. The separation on account of specific gravity is made by passing the entire volume of wheat to be cleaned through currents of air, so as to remove all particles of less specific gravity than the wheat itself. Aside from dust and chaff, various seeds, and especially screenings and other impurities, which are of the same general form and size as wheat, are removed through a difference in weight. The bulk of what is called screenings is not removed by screening, but because of the difference in specific gravity of the so-called screenings and the wheat.

Separations in the cleaning of wheat are also made by means of the difference in the general structure of the wheat and the impurities. For instance, often there is smut, or ergot, and other frail substances which are of the same size and specific gravity as the wheat. Hence they cannot be removed, either by the screens of the separators, or by the air currents which recognize the difference in specific gravity. It so happens that the smut is a frail, brittle substance, which is readily broken by friction which will not disturb the wheat.

If the grain containing particles of this kind is passed into a perforated cylindrical jacket in which there are revolving arms, or beaters, or iron disks, or brushes running together, the smut is broken in pieces, and by means of an air current is drawn out through the perforated cylinder. This changes the gravity and size of the substances, and admits of a distinct separation. With bits of clay and dry earth, the particles being of the same size, form, and specific gravity as the wheat, and not being readily broken, it remains to take other measures to make a separation than those above stated.

In practice it has been found that it is necessary to moisten the entire body of wheat, which process has the effect of softening the particles of earth, and admits of their disintegration by the same machines which make the separation of the smut and other frail substances. The clay is not frail, but is made so by being moistened.

Aside from the removal of the foreign impurities, there are also the impurities which are attached to the grain, the vegetable fiber and hairs which are a natural part of the growth of the wheat. Such impurities are removed by the scouring machines, which are constructed with the various friction devices inside of a perforated cylindrical jacket. This jacket is about the size of an ordinary barrel, is made of light steel, with perforations in it in the form of narrow slots. The friction devices may be in the form of the revolving arms of beaters, as mentioned, or a cylindrical brush which comes in contact with the jacket, or disks made up of stone or iron, or brushes which come closely in contact with one another. These revolving surfaces may be arranged vertically or horizontally. Their principle of operation is the same. The wheat, as it passes through the jacket, is rubbed or scoured in a way to remove the attached impurities mentioned. The current of air drawn by fans into the jacket and outward through the perforations has the effect of removing the attached impurities.

The other foreign substances which remain to be separated from the wheat, and which cannot be removed according to any of the general principles named, are the metallic substances, nails, screws, bits of wire and metal in all shapes and forms. Such particles, if they should get into the mill with the wheat, would injure the machinery to a greater or less degree, according to its delicacy. To make separations of this kind, magnets are arranged so as to temporarily interrupt the passage of the wheat through the various parts of the mill, at which times all metallic substances are attached to and retained by these magnets, from which they may be readily removed.

The arrangement of the machines used in the process of wheat cleaning is various. First may be the magnetic separator, then the separator proper, which is arranged with a suction fan to make separations as to specific gravity, as well as to make the separation as to the differences in form and size of certain of the impurities which the wheat contains. After this separator comes the cockle machine, as it is called, or the round seed separator. Following this are the scouring machines, of which there are usually two different kinds of varying severity, and through which the wheat passes successively. Next comes the last metallic separation by the magnets, and finally the passage of the wheat by means of conveyors and elevators to the stock bins over the reduction machinery.

During the last twelve or fifteen years, the process of milling has been entirely revolutionized. There is no more resemblance between a modern mill and one of the past than there is between a flour mill and a saw mill at this time. According to the old millstone method, after the wheat was cleaned it was ground by millstones. These were made very rough and sharp, so that they would pulverize the grain and rub most of the flour from the bran. In this severe effort the bran was pulverized to a great extent, and the flour affected thereby. The germ was rasped into fine pieces and went into the flour, to its great detriment, as did also the fibrous interior of the grain.

The middlings idea changed all this. It cared for the wheat in a gentle way. It disturbed the bran as little as possible, and neither this nor the germ found its way, in any serious proportion, into the high grade flour. The fibrous interior of the wheat was to a certain extent rendered removable in middlings milling. It remains to tell what middlings milling is. First, it may be said that middlings are particles of wheat. If we should take a knife and cut wheat into small pieces, and detach the interior portion from the bran, we would have middlings. Or if we should in any other way break the wheat without making it into flour, we would make middlings. Middlings are made because when the wheat is in this form it can be still further cleaned, or purified, as it is called when we clean middlings. Middlings purification is nothing more or less than a wheat-cleaning process, and is carried forward according to some of the same general principles. The wheat is broken into pieces, so as to detach and liberate certain of the impurities which cannot be detached while the kernels are whole.

This is the essence and logic of the middlings idea. Middlings were always made on millstones, even before their value was understood. They were made incidentally, and not intentionally, before the recognition of the value of the middlings idea. In 1836, Oliver Evans, the pioneer in milling literature, said: "Although we may grind in the best manner we possibly can, so as to make any reasonable dispatch, there will appear in the bolting a species of coarse meal called middlings." The miller was never able to arrange his burrs so that he could avoid the production of middlings. It was in the effort to do something with this unavoidable product that the milling system was revolutionized. We have had mutterings of the middlings idea in this country ever since 1860.

The first account we have of absolute milling for middlings was at Northfield, Minn., in 1866. This was done by grinding high, by raising the millstones higher than was usual, by avoiding an effort to clean the bran. No general effort was made, however, to make middlings in this country until the purifier was developed. The purifier is a machine which separates the impurities which are detached from the middlings during the process of their production. At first these purifiers were made to handle only the middlings that were made incidentally. The miller took the middlings that were otherwise sold as feed, and ran them over these machines. Having value only as feed, as little as possible of this kind of stock was produced. However, the purifier developed the fact that from the middlings the best flour could be made. The reasons were, as has been previously stated, that the wheat particles could be made cleaner by the aid of the purifier than was possible by the other machinery of the mill. Hence every effort was made to increase the production of this kind of stock. The miller reduced the speed of his burrs, grinding much slower than ever before. He ground higher, that is, with stones farther apart, all for the purpose of producing these pieces of broken wheat called middlings, and as he produced more middlings he had to have more purifiers. All previous ideas of burr grinding were set aside, and the miller only thought to do something to his burrs to make them produce more middlings. This led to endless changes and experiments, and constituted "new process" milling.

To repeat: Middlings purification is simply a species of wheat cleaning, and the wheat is broken into middlings for the purpose of further cleaning or purification. The thorough purification of middlings makes pure flour possible. Pure flour is patent flour. As wheat cannot be purified in its original form, other means were adopted. Purification is now the sum and substance of modern milling. Reduction is a detail, and in so far as a system of reduction aids in the purification of a stock, it is a good system. Modern milling is a wheat-cleaning and wheat-reducing process. If it were possible to make it all middlings, it would be possible to make nearly all of the wheat into patent flour.

As the purification of middlings means the removal of certain impurities, the basis of the separation must be considered. These impurities are the vegetable hairs, the bran which is attached to the middlings, and that which is free in the middlings, the germ with its coatings and surroundings, and the interior cellular coatings. According to the present method, the basis of purification is size, specific gravity and general structure. Thus it will be seen that the same general conditions apply to the separation of impurities from middlings as from wheat. Differences in size, specific gravity, and structure are the conditions which make the purification of middlings possible. They suggest the construction of purifying devices. The separation as to size is accomplished by the means of bolting cloth, and as to specific gravity by air currents which allow the heavier particles to pursue one course and the lighter ones another. As to the structure, the separations are made by means of reduction machines, which allow the impurities to remain intact. For example: The smooth rolls may be mentioned as making a germ separation. These rolls are simply two dressed chilled iron cylinders, running together in a way to crush anything which comes between them. Stock which contains germ, when run between smooth iron rolls, is smashed or broken. The middlings portion is broken and the germ is flattened. The middlings are made smaller and the germ larger. Thus, by passing the body of the reduced stock over a reel, it may be clothed so as to allow the middlings to pass through the cloth and the flattened germ to pass over it and thus separate it from the better stock. The separation as to size and specific gravity as ordinarily made, as every miller knows, is on a vibrating sieve machine, with a current of air up through the sieve. The current is caused by a rapidly revolving fan which is placed over the sieve. The lighter impurities go in the direction of the air currents, and the purer stock through the cloth. There is a class of impurities which is larger and heavier than the good middlings which pass over the tail of the cloth and thus are separated from the pure middlings. The sieve motion in itself has a tendency to aid in the work of purification, being calculated to make all of the light impurities come to the top and the pure middlings stock, which is heavier, cling closer to the cloth and pass through it in due time. The motion of the sieve has the quality of bringing all the light particles to the top, and they float to the place where the suction from the fan is heavy enough to lift them from the cloth and blow them into the dust collectors which are placed over the machines. If not, this stock floats over the end or tail of the sieve.

There is another type of purifier called an aspirator. It is something like a wide spout, into which the middlings are allowed to fall, and as they pass downward through it, the course of the stock is interrupted by slats at the same time that there is a suction or blast of air through the middlings. This has the quality of drawing out light material. In any case it is usual to grade the middlings into different sizes. By grading is meant the separation of the different sized middlings so that each class may have a purifier or number of purifiers to itself. This is done so that the suction of air may be adjusted to suit the different qualities of impurities which may be in each grade of middlings. If one were to put all sizes of middlings, coarse and fine alike, on a single purifier, it would be found that either the middlings would not be well purified, or that they would be wastefully purified.

Where there is a wide range of sizes of middlings to be handled, it will be found that there are impurities which belong to the coarse middlings which are heavier than the lighter middlings. Hence a suction of air which would be intended to remove the impurities from the heavy middlings would draw out the fine middlings as well, and thus cause great waste; or, if the current of air were adjusted so that it would not do this, it would not effect any good in the purification of the coarse middlings in the case. Thus it is that middlings should be

graded into different sizes, so that the suction may be adjusted to purify the middlings and yet not do it wastefully. Material which is lighter or of less specific gravity than good middlings may be removed by currents of air as here stated. The impurities which are larger than good middlings will pass over the end of the sieve and thus, theoretically, the material which goes through the cloth is middlings purified of everything but the germ. Practically this is not true. The middlings have to be handled a number of times in order to make a separation which is satisfactory.

The first purifier made in this country was in 1868, and was used in a mill owned by the Lacroixs at Faribault, Minn. It was described by Rodney Mason, the patent attorney, as a box with a sieve on top of it, and a current of air passing up through the cloth. This is practically what an ordinary sieve purifier is to-day, excepting that the sieve is inclosed by the box. The Lacroix purifier here mentioned had a blast from below, whereas it is common at this time to have a suction fan above. Theoretically the result is the same—the air passes upward through the cloth. In the purification of middlings I have described how the separation as to size and specific gravity is made. It frequently happens that there are impurities attached to the middlings, pieces of bran and fiber. These can only be removed by the process known as sizing, that is breaking them lightly between smooth iron rolls, then taking out the dust by passing the middlings through a reel, and finally grading them again, after which they may be run on to purifiers and repurified. This sizing, dusting and repurification idea is sometimes continued a number of times, until the middlings all become very fine. During this process all of the germ is entirely separated from the middlings, and by the operation of sizing and repurification, all of the bits of bran and fiber which were attached to the middlings are removed. The sizing has the quality of changing not only the relative size of the middlings and impurities, but at the same time the relative gravity. The middlings are made smaller and the branny particles remain the same size as previous to reduction. Hence they are relatively larger, and thus easily removed from the stock.

I have dealt at length with the middlings and their purification for the reason that it is the middlings idea that led to the milling revolutions. I have delayed speaking of the reduction of the wheat because the method of reduction, as compared with the middlings idea, is a mere detail. Reduction of wheat is for the purpose of producing middlings that they may be purified. If wheat could be thoroughly purified without making middlings, then there would be no need for the purifiers. Then reduction would become the sum and substance of milling. But as wheat cannot be thoroughly purified, except in the form of middlings, the middlings idea is dominant. After the introduction of the purifier, after the importance of the middlings idea was thoroughly understood, every miller gave his attention to increasing the proportion of middlings from the wheat. This was the "new process" milling. The millers did all that could be done in the way of producing middlings by millstones, and were not satisfied.

The first roller mill built in this country was a hundred barrel experimental mill, built in one end of the Washburn "C" mill, at Minneapolis, in the winter of 1878–79. It was called an experimental mill, whereas there was no experiment about it. As early as 1875 the roller flour of Buda-Pesth, Hungary, had achieved a worldwide reputation, and was generally appreciated outside of that country. The rollers were machines that would make more middlings than burrs would. That was the sole reason for their adoption by the American millers. The middlings are made on corrugated rolls, or those with small corrugations or grooves cut into them. The number varies as the breaks advance. That is, the corrugations for the first breaking of the wheat are coarser than the others. From four to eight corrugations to the inch are used on the first break, and on the last break twenty-four corrugations to the inch is common. On the intermediate breaks, intermediate corrugations between the coarsest and the finest are used. With the introduction of rolls for reducing wheat came "gradual reduction milling," a term which means just what it says. The reduction is gradual. The first reduction is intended to merely split the wheat, after which it is sent to a short reel clothed with wire cloth of 18 to 20 meshes to the inch, through which the middlings and dust pass. Over the end or tail of the reel pass the broken particles of wheat, which are spouted to the second reduction, where the wheat is broken a little more, and the operation of scalping on the wire covered reel is repeated, and so on ordinarily to the sixth time.

Middlings are usually made during the first five reductions. The sixth or last reduction is exclusively a bran-cleaning process, an dmakes only flour. The flour of the first break is very poor, and for that reason the product of the first break scalping reel is sent into a separate reel by itself, for the purpose of separating the middlings from the flour. The middlings from this break are sent in with the other middlings to be graded and purified. The product of the scalping reels of the second, third, fourth, and usually the fifth break is sent to a reel by itself, to separate the middlings from the flour stock. These middlings, together with the first break middlings, are sent into a grader, which is usually a reel covered with different numbers of cloth, according to the size of the middlings, and thence the middlings are sent to the various purifiers. The flour stock which is separated from the middlings which come from the scalpers as stated is sent into other reels to be rebolted. The flour product of the second, third, fourth, and fifth break is called bakers' or clear flour.

There is a material made by the break rolls and other rolls which is too fine for middlings and too coarse for flour. It is called dust middlings. It is so fine that it cannot be purified without great waste. It is reduced on smooth rolls and sent to reels by itself, and the flour is separated from the stock which may pass over the end or tail of the reel.

The stock which passes over the tails of the purifiers and the tails or ends of the reels is called tailings. It in turn is reduced on smooth rolls, and the flour bolted out on reels in the usual way, and the tailings from the tailings reel is again reduced and again bolted. This latter product is usually low grade flour. The tailings from the purifiers is frequently reduced by itself. It is of a higher grade than the other tailings.

There are various types of reels. The scalping reel is usually a short reel intended to separate the coarser from the fine material, which process is usual and frequent in the various stages of modern milling. However, a scalping reel may be any kind of a reel, or of any length. Flouring reels are mentioned in milling literature. They are the reels which rebolt the flour after the flour stock has been scalped or separated from the coarser stock. Such reels are usually clothed with what is known as Nos. 12 and 14 cloth, which are the usual flour numbers, though sometimes numbers a little finer than these, and occasionally numbers a little coarser, are used. Sometimes all of these numbers are used in one mill, that is, the coarser and the finer, as well as the ones mentioned specifically. There are different types of reels. The ordinary six-sided reel, which is 32 in. in diameter, is formed by passing wooden arms through a shaft and securing wooden ribs at the end in a way to form supports for the bolting cloth which passes around the reel. The centrifugal reel is usually a short reel of cylindrical form, with internal wings which revolve much faster than the cloth, or outer cylinder. These wings throw the stock against the cloth and thus operate with great capacity. This is the principle upon which all centrifugal reels are constructed, though the details are various.

The Morse elevator bolt stands alone; it has no imitators. It is made up of an inclined sieve or screen of bolting cloth, on one side of a frame, with a wide elevator at the other side. This elevator continuously elevates the stock and throws it against the screen. The flour passes through the cloth and the other stock gradually works down toward the other end of the screen to be rebolted or reduced by smooth rolls. Another class of reels is sometimes called the inter-elevator type. The Jonathan mills reel is the pioneer and is representative of this class. It is a cylindrical reel, covered with bolting cloth, and has an interior cylinder of wood of a form closely resembling coarse corrugations of say 3 or 4 in. each. They are close to the cloth, and thus keep the material which is in the reel from thrashing around and being handled in a severe manner.

There are various combinations and arrangements of rolls, reels, and purifiers. There is the centrifugal system, which derives its name largely from the extended use of centrifugal reels. Prominently before the milling public at this time is the short system of milling. It has to do largely with the reductions. Instead of making the five or six reductions which are usual in a gradual reduction mill, only three or four are used. There are two divisions in the general short system idea. One class discards the middlings idea, and attempts to make flour only with the break rolls. The other still retains the middlings idea. The short system idea is prominently in use only in the winter wheat section at this time.

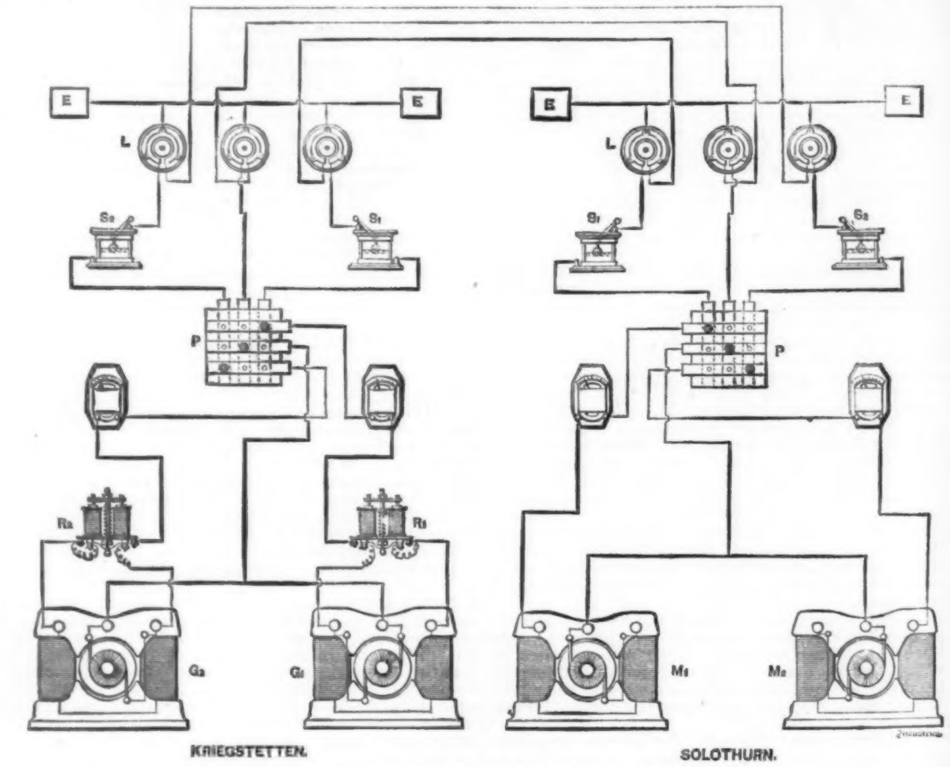
There is a naturalness in the construction of mills which in itself makes them wonderfully picturesque in their interiors. The long lines of rolls have a military air. The grinding floor view indicates this. The purifiers, with dust collector on the top, the spouts and pulleys and conveyors and all make a splendid picture. People are in the habit of raving over the picturesque qualities of old mills. They are admired more as dilapidations than anything else. I am constrained to believe that while few people have thought of it, nothing can be more beautiful and picturesque in a constructive way than the interior of a modern flour mill. The play of light and shade among the spouts, the perspective of the long lines of machines, the uniform movements of the shafting and pulleys, the military precision of the elevator legs, the rude strength of the posts and girders, the whipping of the lighter belts as they pass over the pulleys, and the ponderous movements of the main drive and heavier belts, the thunder of the gearing, the musical hum of the fan—all contribute to the wonderful combination—a combination which is not appreciated for the reason that few people think of it as anything more than a money-making or a money-losing device.

The popular character of the title of this article might suggest that it was gotten up in the "every man his own miller" spirit. The easiest way to get around this is by saying that it is not so. It was the purpose to write something about modern milling which will partake of the spirit of the times, and possibly interest or instruct those who are not immediately associated with milling facts, but who are more or less interested through indirect connection with the milling business. It may be of interest to the millers because of the primer method of the exposition of the ideas herein contained.—*Northwestern Miller.*

ELECTRIC TRANSMISSION OF ENERGY.

A committee was appointed, under the presidency of Professor Amsler, of Schaffhausen, the well known inventor of the planimeter, and the following gentlemen were members: Professor Weber, of the Zurich Polytechnic School, and his two assistants; Professor Hagenbach Bischoff, of Basle; Professor Veith, who occupies the chair of machine construction at the Zurich Polytechnic School; Herr Keller, engineer to Messrs. Escherwyss, of Zurich; Herr Lang, a manufacturer of Derendingen; and Herr E. Burgin, of Basle, the inventor of the Burgin dynamo. This committee have just issued their official report on the trials made on the 11th and 12th of October last with the plant as actually installed. Before quoting the results of these trials, it will be well to briefly refer to the general arrangement of this installation.

At Kriegstetten there is a water power available, representing about forty actual horse power, and the problem was to carry as much of this power as possible to a mill in Solothurn, the distance being 4¾ miles as the crow flies; but, allowing for deviations, the length of each circuit may be taken as about five miles. There are at Kriegstetten two generating dynamos, and at Solothurn two motors coupled up on the three-wire system, as shown in the illustration below. Each dynamo weighs 3 tons 12 cwt., and has a Gramme armature 20 in. diam. and 14 in. long, the normal speed being 700 revolutions per minute. Referring to the diagram of connections, G^1 and G^2 are the generators



ELECTRIC TRANSMISSION OF ENERGY.

at Kriegstetten, and M^1 and M^2 are the motors at Solothurn. R^1 and R^2 are electro-magnetic switche swhich automatically come into action and short-circuit the exciting coils in case of the current rising beyond a certain limit. This provision was introduced in order to guard against the destruction of the generator in case a short circuit should take place somewhere in the line.

The current from each generator passes through an ammeter and then to a plug board, to which is also connected the balancing wire joining the negative brush of G^2 with the positive brush of G^1. The balancing wire is then carried direct to the middle one of the three lightning arresters, L, and then to the middle wire of the line, while each of the outside wires is led through a liquid switch, S^1 S^2, then to lightning arrester, and to the line. Each lightning arrester consists of a circular metal disk, the edge of which is provided with projecting teeth, and situated in a concentric metal ring, the internal circumference of which is also provided with teeth, but not touching the teeth of the disk. All the disks are connected with a common earth wire and two earth plates, E E. Should a flash of lightning strike the line, the current will leap across the intervening space between the teeth of the ring and those of the disk, and will thus be led to earth without passing through the machinery. The same provision against lightning is made at the motor station. The switches, S^1 S^2, are of peculiar construction, and consist of a vessel containing a conducting liquid and a perforated metal ball dipping into it. When the current is to be switched off, the handle is turned so as to raise the ball out of the liquid; but the circuit is not immediately interrupted, since the liquid within the balls issues in fine streams out of the perforations, and so maintains the connection for a short time after switching off. As the liquid in the ball gets exhausted, and the streams become thinner, the resistance of the liquid connection is gradually increased to infinity, and thus causes the current to gradually diminish to zero. The line wires are supported on Johnson & Philips' patent fluid insulators, and the average

span is about 130 ft. Two sets of experiments were made. On the 11th October only one generator and one motor were tested, while on the 12th October both generators and both motors were tested. In the latter test the balancing wire was cut out of circuit as of no importance when, as in these experiments, it was quite easy to regulate the load of each motor so as to fairly divide the work between them.

Electrical measuring instruments were fitted up at both stations in rooms sufficiently distant from the machinery, so as not to be influenced by stray magnetism. The current was measured by large tangent galvanometers, and Thomson mirror galvanometers, standard cells, and potentiometers were used to measure the pressure. The object in measuring the current at both ends of the line was to ascertain whether any appreciable leak took place. In addition to these purely electrical measurements, observations were made at the generator station regarding the water level in the head and tail race of the turbine, the position of the regulator on the latter, and the speed of the dynamos and turbine. After the transmission trial on the 11th October was completed, the armature of the dynamos was taken out and replaced by a plain spindle provided at the end with a brake. The turbine was then started again under exactly the same conditions as were noted at the previous trial, and the power absorbed by the brake was measured. The comparison between the power thus measured and the electrical energy given out by the generator is evidently the commerical efficiency of the latter. On the following day both generators and both motors were tested in the same condition as prevails in actual practice, with the only exception that, as already mentioned, the balancing wire was cut out of circuit. This alteration, which could obviously not increase the efficiency of the whole system, was made to simplify the measurements. The power absorbed by the generators was computed on the basis of the previous day's trial from the observed conditions under which the turbine worked, while the power developed by the motors was on both days directly ascertained by means of a friction brake fitted to a first motion shaft common to both motors. A small correction was made for the power absorbed by this shaft when running idle. The following tables give the results as published by the committee:

I.—ELECTRICAL MEASUREMENTS.

Time of trial.	Electromotive force.		Terminal pressure.		Current measured at	
	Generators.	Motors.	Generators.	Motors.	Generators.	Motors.
11th Oct.	1231·6	988·6	1177·7	1041·2	14·20	14·17
" "	1237·0	1016·8	1186·8	1066·1	13·24	13·28
12th "	1836·5	1575·4	1753·3	1658·1	11·48	11·42
" "	2129·0	1896·2	2058·0	1965·2	9·78	9·79

II.—RESISTANCES AND LOSS OF PRESSURE.

Time of trial.	Resistance of machines.		Line resistance.	Pressure lost in line.		Temperature of air. Centigrade.
	Generators.	Motors.		Calculated.	Measured.	
11th Oct.	3·741	3·716	9·228	130·9	136·5	+7·5
" "	3·741	3·710	9·228	122·3	120·7	+7·5
12th "	7·251	7·060	9·044	103·7	97·2	+3·2
" "	7·240	7·042	9·040	88·4	92·8	+3·2

III.—DETERMINATION OF ENERGY.

Time of trial.	Internal electrical horse power.		Terminal electrical horse power.		Actual horse power.	
	Generators.	Motors.	Generators.	Motors.	Supplied to generators.	Obtained from motors.
11th Oct.	23·76	19·03	22·72	20·02	26·15	17·85
" "	22·27	18·34	21·35	19·23	24 54	16·74
12th "	28·64	24·46	27·34	25·71	30 87	23·21
" "	28·29	25·21	27·37	26 13	30·87	23 05

IV.—PERCENTAGE OF EFFICIENCIES.

Time of trial.	Electrical efficiency.		Commercial efficiency.		Total efficiency of transmission.	Remarks.
	Generators.	Motors.	Generators.	Motors.		
11th Oct.	90·8	93·7	86·8	89·1	68·3	One generator and one motor.
" "	90·6	91·3	86·9	87·1	68·2	
12th "	92·8	94·8	88·5	90·3	75·2	Both generators and both motors.
" "	91·6	91·4	88·7	88·2	74·6	

An inspection of these figures will show that there is practically no loss of current by leakage on the line. In some cases the current measured at the motor station is slightly below that measured at the generator station; but the discrepancy is exceedingly small, and evidently due to personal or instrument errors, since in some other cases the current received by the motors appears to be even slightly larger than that sent out by the generators, which is obviously impossible. The second table also shows the influence of the air temperature upon the total resistance. The third table gives the power, and the fourth the efficiencies in percentages. It will be noticed that when one generator and one motor only were used, the commercial efficiency was slightly over 68 per cent.; but when both generators and both motors were used, this efficiency rose to about 75 per cent., which is clearly due to the higher voltage employed. On the whole, the result of these trials must be considered highly satisfactory, and Mr. C. E. L. Brown can be congratulated upon having succeeded in transmitting power over a distance of five miles with a loss not exceeding 25 per cent. It is needless to say that so high an efficiency could not possibly have been attained with any purely mechanical system of transmission.—*Industries.*

THE TELEPHONIC BULLET PROBE.*

By JOHN HARVEY GIRDNER, A.B., M.D., New York.

I FIRST presented this instrument to the profession at a regular meeting of the Academy, on February 3, last year. I bring it before the surgical section again

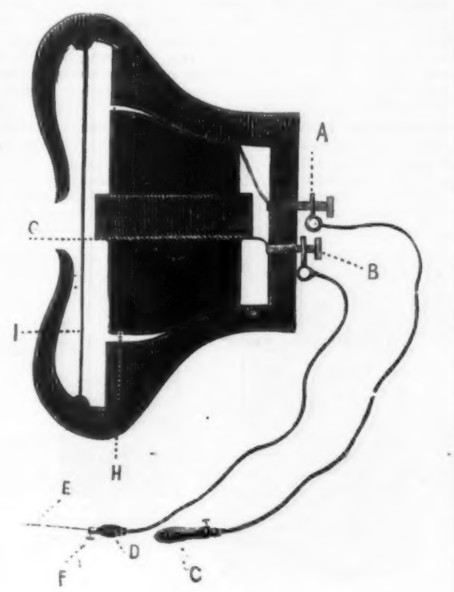


FIG. 1.

this evening, because, by certain improvements I have been able to make, it is now perfect, and a year's clinical experience has demonstrated its superiority over all other bullet probes.

But I also desire to ask your attention, for the first time, to the novel and interesting principle on which the instrument is operated, viz., by a current of electricity extracted from the body of the patient himself in whom it is desired to locate a metallic missile.

The construction of the telephonic probe is as follows:

To each of the two terminals of a telephone receiver, A and B, Fig. 1, an insulated flexible wire about four feet long is connected.

At the free end of one of these wires a hollow, bulbous piece of steel, C, is attached. At the free end of the other wire is a suitable handle, D, in which a probe, E, may be placed, and held by the clamp screw, F.

The internal arrangement of the handle must be such

FIG. 2.

that a perfect electrical contact shall exist between the end of the probe and that of the wire which terminates in the handle; the same is true for the end of the other wire and the steel bulb.

The receiver, R, Fig. 1, is shown in perpendicular section. The framework is of hard rubber, and the internal construction is as follows: In the center is a small bar of soft iron, marked G; around this bar a coil of insulated wire, H, is wound; the two ends of the coil pass backward and connect with the terminals or binding posts, A and B; the end of the soft iron bar is seen to protrude a little beyond the coil, and near it, though not in contact, is suspended a metal diaphragm, marked I. Now, if a current of electricity be passed through the coil in the receiver by means of bulb, C, and the probe, E, a magnet will be made of the soft iron bar, G, and it, in turn, will attract the metal diaphragm, I, causing it to vibrate, and each time the current is made and broken a clicking or rasping sound is heard in the receiver held to the ear.

Fig. 2 shows two such receivers as I have described, attached to a flexible steel band; the short wire seen in the cut passing from one receiver to the other is to complete the circuit between them. When the steel band is placed over the top of the head, the receivers fit snugly against both ears, as seen in Fig. 3.

This arrangement has the advantage of leaving both hands of the operator free. It also shuts out all sound except that heard when the bullet is touched. A single receiver, however, held to the ear with one hand, leaves the other free, and answers perfectly for all practical purposes. A single receiver might also be held to the ear by means of an elastic band, such as is used to hold a head mirror.

So far as I know, only the single instrument is to be found for sale in the shops at present.

We pass now to the practical application of this instrument.

To illustrate, I will describe a case seen in practice. A musket ball had lain between the tibia and fibula for twenty-two years. A long, narrow, tortuous sinus had been discharging for a year. When an ordinary probe was passed, hard substances could be felt in many places; but you could not tell if bone or bullet was being probed. The porcelain probe could not have been marked by the lead, owing to thick crusts of salts of lead with which the ball was covered, even if it could have been brought into contact with the bullet, which it could not, owing to narrow places in the sinus.

The telephonic probe was now brought into requisition as follows: The steel bulb, C, Fig. 1, was placed in the patient's mouth and the lips closed; the operator held the telephone to his ear, while at the same time he passed the steel probe, E, of the other wire into the sinus. Bone and other tissue were felt as the probe passed to different parts of the wound, but no response was heard in the telephone until the leaden bullet was touched, then an electric current passed through the telephone; and as often as this current was made and broken, by touching and removing the probe from the lead, so often was there a vibration of the diaphragm, and consequently a clicking and scraping sound heard in the telephone; in other words, the patient's body was converted into an electric battery; the body corresponded to the cups, its fluids and heat to the battery fluid, the steel bulb immersed in the mouth to the zinc, let us say, and the lead, when it was touched, to the carbon, and thus our battery was completed, a current obtained, and the metal diaphragm made to vibrate.

In order that you may test the instrument, I will place the steel bulb in this boy's mouth and a piece of lead in his moistened hand; along with the lead I also place a piece of bone in the hand, and you will observe that no response is heard when the bone is probed, but the slightest touch on the lead produces a distinct click or scraping noise in the receiver.

The steel bulb may be placed in the mouth, the rectum, the vagina, or held in the hand, provided the latter is thoroughly moistened, and grasps the steel firmly.

A probe or needle of any metal, shape, or character desired, may take the place of the steel probe now in the handle, provided the bulb at the end of the other terminal be of the same metal as the probe, and both differ from that of the missile to be located.

The advantages of this instrument over all others at once appear when it is remembered that in its use the accurate sense of hearing is substituted for that of the sensation communicated to the hand, which is always unreliable, for no one can tell if a hard sub-

FIG. 3.

stance felt in a wound be bone, metal, or some other hard tissue.

The porcelain-tipped probe was made with the hope of overcoming this difficulty; but after ample experience with the Nelaton probe, both in my own hands and in those of others in my presence, I am certain that, unless the bullet is perfectly clean from grease, lead salts, etc., and very favorably situated, it is not

* A paper read before the surgical section of the New York Academy of Medicine, Jan. 9, 1888.

possible to obtain lead markings on the porcelain tip which can be relied upon to direct our operative procedure. Let any one hold a bullet in the hand, and probe it with a Nelaton probe until the markings of the lead on the porcelain point are perfectly distinct, and he will find that it requires an amount of force and pressure in rubbing the lead which he will rarely be able to make, even in the most favorable cases of gunshot wound. None of the above conditions, which make the Nelaton probe useless, in any way interfere with the perfect working of this new probe, for you see in the experiments which you are now making on the boy, that the slightest touch of the bullet with the probe causes a loud and unmistakable sound in the telephone. Another great advantage is, that a sharp, slender, steel needle may take the place of the blunt probe now in the handle, and then no tract is necessary in probing; the needle, rendered aseptic, may be thrust into the tissues like a hypodermic needle, with little pain and no danger to the patient, as I have verified in actual practice, and when the bullet is struck, you have only to loosen the clamp screw and remove the handle, allowing the needle to remain fast in the tissues, with its point still in contact with the missile, and it serves as a perfect guide in cutting down on the bullet.

We have, then, in this instrument, a simple, cheap, and absolutely accurate means of determining the presence or absence of a metallic missile in a wound, for it responds equally well to iron or other metals as to lead.

Another feature of much interest to me, in connection with the instrument, is the facility with which we obtain a current of electricity, sufficiently powerful to operate the instrument, from the body of the person operated on, as you have seen in the case of this boy on whom you have been experimenting to-night.

This fact, it seems to me, opens an important field for thought and experiment. I have found already that the strength of the current, as indicated in the receiver, varies in different individuals and in the same individual under different conditions.

When we reflect on the chemical processes which are constantly taking place in the living body, and which exceed in extent and variety those of the most powerful electric battery, the above ascertained facts seem to hold out a hope that we may yet discover such electrical differences in healthy and diseased tissues as will greatly aid in the diagnosis and treatment of diseases.

Dr. Franklin sent his kite into the clouds to obtain a spark for experimental purposes. In our day, we find that the living human body yields a current of electricity which can be utilized for a practical and humane purpose.—*Medical Record.*

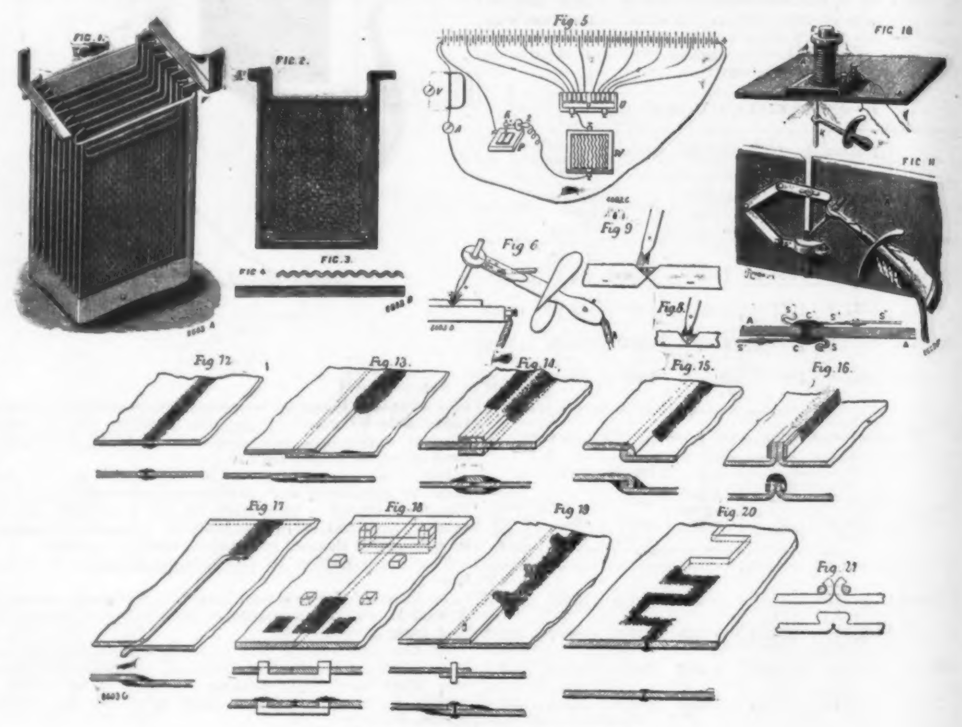
ELECTRICAL WELDING.

A METHOD of welding by electricity, devised by Mr. Nicolas Von Benardos, of St. Petersburg, has recently attracted considerable attention on the Continent, and possesses several features which render it quite distinct from the various processes of fusing and reducing by means of the electric current or the electric arc, proposed from time to time by Siemens, Cowles, Elihu Thomson, Wallner, and others. It seems, moreover, to be thoroughly practical, though sufficient experience has not yet been obtained with it. An account of the process, together with a description of the advantages which are claimed as resulting from it, has been given by Professor Ruhlmann, of Chemnitz, after a careful study of the Benardos process at St. Petersburg; and in the following account we shall follow closely his very able and interesting articles published in recent numbers of the *Zeitschrift des Vereins Deutscher Ingenieure* and the *Elektrotechnische Zeitschrift*, the latter being the substance of a paper read before the Electrotechnical Society of Berlin.

Mr. Von Benardos, says *Engineering*, works directly with the electric arc produced between a carbon pencil as one terminal and the metal to be treated as the other terminal. This has been suggested and tried before. But the carbon was made the negative pole, as it was feared that otherwise the consumption would be embarrassingly rapid. Hence the metal became the positive pole, that is to say, it became exposed to energetic oxidation; and a great deal of the trouble experienced by other experimenters arose from this circumstance. In the Benardos process, the carbon forms the positive terminal; it is, of course, quickly consumed, but can easily be replaced; on the other hand, there is a favorable reducing action going on in the fused metal. The great importance of this modification can easily be tested by changing the poles, when the work soon becomes enveloped in a dense cloud of oxidized products. The intense heat of the arc melts even the most refractory metals almost instantaneously; but the action is purely local, like that of the blowpipe, and only those parts upon which the arc plays directly are attacked, the adjoining portions undergoing little change; and the fused mass solidifies and cools very quickly. In the Benardos process the material requires little or no preparation. Even a pretty thick layer of oxide will be reduced and drop off, while smaller quantities of oxides unite to form a slag with the sandy clay frequently added as a flux. This slag prevents the oxidation of the metals while cooling. No other fluxes are required. The operations can also be carried on under water, although the gases and steam generated cause trouble. Nevertheless, an apparatus has been constructed to facilitate such work by forcing the water away from the parts to be treated by means of compressed air. One of the chief advantages claimed for the new system appears to be that the arc is brought to the work, and not the work taken to the arc, which would mean transformers, crucibles, or other apparatus. Size is hence a question of secondary importance, and unwieldy pieces may be dealt with, although for soldering work of the ordinary kind a special operating table is employed as more convenient. A fortunate accident occurred last summer at the emery works of Messrs. Struve, of St. Petersburg, which directed general attention to his process. The works have a vertical boiler with heaters, some of which had become leaky, and the works were practically at a standstill. The consulting engineer declared that the repairs would be rather expensive, and might occupy three weeks' time. Mr. Von Benardos inspected the boiler, and offered to repair the heaters that very day. The boiler was put on a truck, taken to his works, treated electrically on the truck, and wheeled back, all in three hours. This story sounds almost as if the engineer had been too despondent and the reporter too enthusiastic. However, Professor Ruhlmann assures his readers that he saw the boiler in full action the next working day. Fig. 7 is reproduced from a photograph taken during these repairs, and illustrates the simplicity of the process. We may mention another case which is reported by Professor Ruhlmann. A cast-iron flywheel of more than five tons weight had been broken into several pieces while being taken down from the truck. The pieces were fused together within a few hours, and the following day the flywheel was in place and at work.

A glance at the accompanying engravings will give an idea of the great variety of circumstances under which this process is applicable. It is clear that flywheels cannot be treated in the same way as telegraph wires; and that a soldering and welding plant, to be really useful in the workshop or foundry, should be able to deal with delicate articles of a few pounds or ounces in weight equally well as with heavy pieces. Economy will in general be in favor of one source of power for the various operations; but then the operator must have thorough command over the volts and amperes of his currents if the arc is to have the proper volume and temperature. The length of the arc may, within small limits, be adjusted at will; the currents themselves may be modified with the help of resistance coils. But this is not sufficient. Supposing that the workman has to do a little tin soldering, and to weld two large thick boiler plates a few minutes later, he must be in a position to vary both tension and quantity of the currents within very wide limits. A dynamo alone would not do, there must be accumulators also, and these of a special kind capable of being charged with strong currents and discharged either at a few amperes or at several hundred times that amount. Faure accumulators are not adapted for such work, nor are those of the Plante type, as they cannot store up sufficient quantities of electricity, series; a voltmeter and an amperemeter are inserted at V and A. From the positive terminal of every fifth cell a wire leads to a plug switchboard, U; from U the current passes through a variable resistance, W, and from thence through a flexible cable to the carbon holder, Z, and the carbon pencil, K. The operator manipulates his holder, Z, the metal to be fused, placed upon the table, P, being joined directly to the negative terminal of the battery. By inserting the plug in the switchboard, U, the operator may obtain currents from five cells, twice five, and so on to ten times five cells. If considerable masses of metal are to be dealt with, currents of considerable strength are needed. These are obtained by grouping the batteries or certain sets of cells in parallel. Supposing the dynamo gives currents of 175 volts and 120 amperes, that there is a battery of seventy cells coupled in series, and that it is desired to solder two boiler plates of 10 millimeters (⅜ in.) thickness. The carbon holder is connected with the positive terminals of the fortieth cells of three groups. The carbon pencil is allowed to touch for a fraction of a second, and is taken off again immediately, so that between the plates and the carbon pencil an arc of a few millimeters length is formed. The iron melts like wax; but the action seems too powerful, the molten metal hissing and evaporating distinctly. In such a case one of the three parallel groups is cut out. Should the action then be too sluggish, one or more parallel groups is added. Sometimes the arc proves too small or extinguishes frequently; in such cases the number of cells in each group has to be increased.

The carbon holder (Fig. 6) resembles a pair of scissors, and consists of two copper bars having a round hole near the end, in which the pencil is held firmly, either by the friction of the parts or by means of a little wedge, as shown in the figure. The flexible cable passes through the wooden handle. During working the holder becomes hot, and may have to be cooled by plunging it into cold water. The operator wears strong leather gloves, and his hand is further protected



ELECTRICAL WELDING.

although they bear strong charging and discharging currents. Mr. Von Benardos has constructed accumulators for the work which are not strikingly novel, but seem well fitted for their special purpose. Professor Ruhlmann saw at St. Petersburg some cells in very fair condition which had been in use for more than a year and a half. It is further noteworthy that at the Creil works, where the Benardos processes have been under trial for some time, serious difficulties had to be encountered until the accumulators already there were exchanged for the Benardos battery. The complete cell (Fig. 1) weighs 15·9 kilogrammes (35 lb.) and contains nine lead plates (Fig. 2), all of the same kind, four of them positive and five negative, with 1·25 square meters (1½ square yards) of total surface. Each plate consists of a frame cast of pure lead 16 by 20 centimeters (6 in. by 7¾ in.) surface, and 0·5 centimeter thick (0·2 in.). The interior of the frame is filled with strips of thin lead, alternately straight and corrugated (Figs. 3 and 4), soldered into their places; the latter strips are bent in such a manner as to facilitate upward currents in the liquid. Such currents arise during charging, owing to the development of gas, which, if kept within proper limits, is thought advantageous to these cells; the upward currents equalize the difference in density; the curvature of the bent strips favors the liberation of the small gas bubbles, and checks the formation of larger bubbles, which would cause buckling. Caoutchouc prisms separate the positive and negative plates, the poles of which are simply soldered to stronger lead strips running along either side of the cell. Diluted sulphuric acid of 1·25 specific gravity circulates freely between the plates. The total weight of the complete cell (35 lb.) is made up of 10·5 kilogrammes for the nine plates, 3·5 kilogrammes for the acid, and 1·8 kilogrammes for the glass jars. The cells have an interior resistance of 0·002 ohm and give 2·5 volts, when continually charged while at work. Fifty to seventy of these cells are joined in a battery; several batteries, three for instance, are grouped in parallel, and are continually charged by a shunt dynamo. The sketch, Fig. 5, explains the ordinary connections. The shunt dynamo, D, charges the fifty accumulator cells in by a metal screen fixed on the holder. He looks at his work through a dark glass (Fig. 7), which protects both his eyes and face from the radiated light and heat better than ordinary dark spectacles would do. The lungs also may need protection from the vapors of copper, lead, and other metals or alloys. When possible, means should be provided to carry off such vapors with a blast of air. The construction of the holder permits of a quick replacement of the carbon pencil. The diameters of these carbons vary greatly. For more delicate work, where a few cells would suffice, fine pencils of only 1·5 millimeters ($\frac{1}{16}$ in.) are required; while boiler plates, such as mentioned above, are welded together by means of thick carbon rods of up to 2½ in. in diameter. The carbon is pointed before using it. Ordinary light-carbons do not answer well, as they are generally too soft; the inventor prefers Carre carbons.

One of the most important applications of the new process is for welding plates of all thicknesses. For the very finest sheets of one millimeter and less, the Electro-Hephaest Company prefer, with commendable impartiality, a modification of the Elihu Thomson process, although their own process is sometimes equally good (compare Figs. 26 to 28). But all stronger plates up to several centimeters thickness are subjected to the arc.

To effect this with ordinary plates, the edges are feathered as in Fig. 8 or Fig. 9, and pressed together. The furrows are filled with little pieces of the same material, and the arc is then applied while fresh pieces are added until the furrow is completely filled with the molten mass. The plates are immediately afterward finished under the hammer. In making iron welds the small pieces for filling are always of wrought iron. With iron, a flux of clay sand is recommended, with copper, borax, or sal-ammoniac. The arrangement Fig. 9 secures great strength, but is of course only applicable when the lower surface of the metal can be got at. When the plates are joined on their lower surface, Mr. Von Benardos suggests a powerful electro-magnet placed as indicated in Fig. 10 to prevent the liquid metal (provided the material be para-magnetic

from flowing off; whether this suggestion will prove practical is doubtful. The apparatus shown in Fig. 11 looks more practical: it is intended to be employed when making vertical seams. The pincers, S_1 and S_{11}, carry two pieces of graphite or coke, C_1 and C_{11}, forming a sort of chamber at the spot where the fusion is to be carried on. As soon as the mass has hardened sufficiently, the carbon pieces are pushed further up. Carbon pieces are frequently employed to prevent the flowing off of the fused material. Figs. 12 to 20 exemplify other ways of joining plates in cases where a perfectly straight surface is not insisted upon. For thinner plates the method, Fig. 16, seems to offer particular advantages; for two ½ in. plates a seam of a yard length can be made in seven minutes. When plates are to be joined at an angle, the process is of course exceedingly simple.

If two iron bars are to be joined end to end, the one bar is roughly centered in a lathe, and the other pressed against it; the body of the lathe is connected with the negative pole. A few momentary touches with the carbon will make the two bars stick together sufficiently so that they move as one piece with the lathe. While the lathe is turned slowly, the welding is effected by the addition of material in small quantities at a time. To join two telegraph wires, the ends are bent (Fig. 21), a little iron ring is pushed over the hooks, and the whole fused into a sort of button; the resulting joint leaves nothing to be desired as to conductivity and breaking strength, and the whole operation can be accomplished with a few cells, and in two minutes for four-millimeter wires.

So far we have only spoken of joining materials of the same kind. But the intense heat of the arc supplies alloys which are hardly known under other circumstances, so that iron and copper, tin, zinc, lead, steel, cast iron and steel, wrought iron and steel, aluminum and platinum, etc., can be united. This promises important progress in the working of metals. Professor Ruhlmann has exhibited specimens of iron plate welded to red copper, iron plated with tin, and iron plated with lead. In such cases there is probably at the junction of two metals a layer of alloy. Chemical manufacturers would be thankful for cheap copper retorts coated inside with platinum, or iron vessels coated with lead. Professor Ruhlmann saw at St. Petersburg a number of copper tubes soldered into a cast-iron plate, and this iron plate coated with copper several millimeters thickness.

If the metals can be joined by the electric arc, they can also be separated by the same means. For instance, holes can be made if the metal is permitted to flow off. To pierce a hole 1 in. in diameter through two plates of ⅛ in. thickness takes about four minutes. The next step is to rivet the plates in this way; this is shown in Fig. 19, where the plates are ½ in. plates, the rivet ¾ in. thick, and the operation took eight minutes. It seems, however, more advisable to punch or drill the holes.

It has been said, above, that the materials undergo little chemical change under this treatment. The question seems very important for iron, whose behavior is so remarkably influenced by slight variations in the composition. To test this question, wrought iron droppings from the welding process were fused again by means of the arc to a bar of about 15 millimeters thickness, and this bar turned down to 10 millimeters. The breaking weight of this bar was 37·5 kilogrammes per square millimeter (23·8 tons per square inch), with an elongation of 17·5 per cent. The fracture was fibrous, like that of soft steel. This electrically fused iron (Fig. 34) resembles soft steel in other respects, notwithstanding its origin; it is malleable, can be welded, can be bent both cold and hot, and is scarcely harder than soft steel. The following table gives analyses made by Mr. P. M. De la Vieuville. The columns B refer to the original metal before electrical treatment; the A columns show the composition of the metal after the treatment. The changes are slight, and appear rather favorable.

	B.	A.	B.	A.
Steel.				
Carbon	0·44	0·22	0·52	0·29
Silicon	0·03	trace	0·05	trace
Manganese	0·57	0·14	0·42	0·36
Sulphur	0·041	0·036	0·039	0·035
Phosphorus	0·102	0·100	0·07	0·050
Iron.				
Carbon	0·38	0·15	0·30	0.13
Silicon	0·03	0	trace	0
Manganese	0·33	0·16	0·36	0·30
Sulphur	0·160	0·120	0·110	0·070
Phosphorus	0·127	0·124	0·105	0·087

The tensile strength tests of electrically made joints yielded most satisfactory results. Two pieces of rolled charcoal iron, joined as in Fig. 12, showed a breaking strength of 28·5 kilogrammes per square millimeter (18 tons per square inch), the iron itself giving 32 kilogrammes; the elongation was 9 per cent. In another instance 93 per cent. of the initial tensile strength was observed. A plate riveted electrically rent finally outside the riveting line. The electrical riveting or the joining of plates without rivets, particularly as in Fig. 20, seems to offer material advantages for some purposes.

ELECTRICAL WELDING.

The remaining figures illustrate specimens exhibited by Professor Ruhlmann before the Electrotechnical Society. Fig. 22 is a cast iron plate, Fig. 23 a cast iron eccentric, broken in pieces and joined again at *a*; the junction is said to be quite homogeneous and neither harder nor more brittle than the solid metal. This suggests the finishing of cast iron pieces by means of the electric arc. Fig. 24 represents a piece of a cask, Fig. 25 part of an iron boat. That even finer plates may be subjected to this process is demonstrated by Figs. 26 and 27; but as already remarked, for very fine plates and wires the Elihu Thomson process appears preferable. Fig. 28 is a specimen of neat workmanship, a little steam boiler, formed out of three pieces, shell, top, and bottom. A section through an electric rivet is illustrated in Fig. 30; Fig. 31 shows how the so-called half rivet is made, and Fig. 32 how stronger bars are joined. In Fig. 33, a bar welded in this manner has been bent cold under the hammer at right angles at the line of junction. The specimen Fig. 34 consists entirely of electrically fused iron which has already been described; it has been bent cold without showing any fissures or irregularities. The shaft, Fig. 35, was formed by fusing together three pieces. The iron tube, Fig. 36, was welded at *a*, and provided with a flange at *b*, by the same process; the copper tube, Fig. 37, is also a specimen of electric welding. Fig. 38, finally, is a turning tool of ordinary iron with a steel bit welded to it.

These instances do not cover the whole field where electric welding and soldering might advantageously be applied. Chains may be produced with welded links, tools provided with steel points and edges, cables joined, pans made without rivets and plated, and many kinds of repairs, especially in cast iron, become possible. The process will probably be studied with particular interest by the shipbuilder. The cost of such a welding plant would not be heavy. The dynamo and accumulators could weld and repair during the day and provide light in the evening. This would be one more reason for introducing electrical power into the workshop. The "Electro-Hephaestos" of St. Petersburg has taken up these inventions, and in Russia the processes have been introduced at the well known works of Messrs. Struve.

THE GREAT TELESCOPES OF THE WORLD; THEIR CONSTRUCTION, POWERS AND LIMITATIONS.

By Prof. JOHN K. REES.

LIKE all great inventions, the telescope may be considered the product of many minds. The inventor was one who worked out the proper combination of lenses, or mirrors with lenses. Long before the invention of the telescope, spectacle glasses or lenses had been made. In the eighth century A. D., magnifying spectacles for old people were commonly used. Seneca, who lived in the first century, tells us that, in his time, it was well known that when writing was viewed through a globe full of water, the letters looked larger and blacker. This appearance must have attracted the attention of many persons before the time of Seneca. The natural result of such a discovery would be the invention of glasses to produce magnification. It is not strange, then, that we find the use of a simple magnifying lens extending so far back that we are unable to fix the date for its discovery. But, down to the beginning of the 17th century, no one seems to have thought of combining two lenses together, one in front of the other, so as to render distant objects visible.

There appears to be some uncertainty as to the name of the original inventor of the telescope. Undoubtedly, Galileo was the first to publish to the world the manner of making the instrument, and, furthermore, he was probably an independent inventor; but it is well known that he was not the original inventor. In the archives of the Hague, quoted by Arago, we read that a spectacle maker of Middleburg, named John Lippershey, addressed a petition to the States-General on October 2, 1606, in which he asked leave to take out a patent which should constitute him the only maker of an instrument capable of rendering distant objects visible, or which should confer upon him an annual pension, on the condition of not manufacturing the instrument for other nations. On the 4th of October, 1608, the States-General appointed a deputy from each province to experiment on the new instrument, which was about one foot and a half in length. On the 6th of October, the commission declared the instrument to be useful to the nation, but demanded that it should be made for two eyes instead of for one. On the 9th of December, Lippershey announced that he had solved the problem. A favorable report was made on the 11th, and the binocular instrument was declared a success.

"Saturnus tells us that an unknown man of genius called on Lippershey, and ordered from him a number of convex and concave lenses. At the time agreed upon the man returned and chose two lenses, one convex and the other concave, and placing them one before his eye and the other at some distance from it, drew them backward and forward without giving any explanation of his maneuvers, paid the optician, and left the place. As soon as he was gone, Lippershey began to imitate the experiments of the stranger, and soon found that distant objects were brought apparently nearer when the lenses were placed in certain positions. He next fastened them to the ends of a tube, and lost no time in presenting the new instrument to Prince Maurice of Nassau."

According to another version, Lippershey's children were playing with the lenses, when one of them, happening to place a convex lens in front of a concave lens, was greatly surprised to see the vane of the clock tower of the Middleburg church apparently brought nearer. Lippershey's attention being called to the fact, he tried it, and working out the idea, he invented the first telescope.

Metius, of Amsterdam, the discoverer of the ratio $\frac{355}{113}$ (the relation between the circumference and the diameter of a circle), claimed to be the inventor. Jansen and Baptista Porta and others disputed for the honor.

Inasmuch as the first telescopes were at once seen to be of great value in wars, it was attempted to keep the invention a secret. Galileo heard, through letters, that an instrument had been invented which rendered distant objects visible, but he obtained no account of the construction. He, however, on this hint, made a telescope after several trials. The highest magnifying power which Galileo used was nearly 30 diameters. He was the first to direct the telescope heavenward. He saw the spots on the sun, the moons of Jupiter, the mountains in our moon, the handles of Saturn, the phases of Venus, and made other interesting discoveries.

Kepler suggested for the single biconcave lens near the eye, used by Galileo and others, a double convex lens, which gave a larger field. This combination is called the "astronomical eye piece." It inverts the objects looked at.

It is foreign to my purpose to enter into the details of the construction of a telescope. You all know that the power of a telescope to magnify an object looked at depends upon the focal lengths of both object glass and eye piece. It is the ratio of the first to the second. If, then, our object glass forms an image of the moon at a distance of 100 inches from the center of the glass, and we view that image with an eye lens whose focal length is one quarter of an inch, we obtain an image in the field of view which is magnified 400 diameters. We can, therefore, increase our magnifying power either by making the focal length of the object glass greater, or that of the eye lens less, or by doing both. With a given object glass we can, theoretically, make our magnifying power as great as we choose. If, in the case cited, we use an eye lens with a focal length of say $\frac{1}{100}$ of an inch, we obtain a magnifying power of 100 × 100, or 10,000 diameters. "But in attempting to do this, a difficulty arises with which astronomers have always had to contend, and which has its origin in the imperfection of the image formed by the object glass. No lens will bring all the rays of light to absolutely the same focus. When light passes through a prism, the various colors are refracted unequally, red being refracted the least, and violet the most.

"It is the same when light is refracted by a lens, and the consequence is that the red rays will be brought to the farthest focus and the violet rays to the nearest,

while the intermediate colors will be scattered between. As the light is not all brought to the same focus, it is impossible to get any accurate image of a star or other object at which the telescope is pointed. The eye sees only a confused mixture of images of various colors. When a sufficiently low magnifying power is used, the confusion will be slight, the edges of the object being indistinct and made up of colored fringes. When the magnifying power is increased, the object will indeed look larger, but these confused fringes will look larger in the same proportion, so that the observer will see no more than before. This separation of light in a telescope is called chromatic aberration."

The early astronomers found no way to get rid of this difficulty. They discovered, however, that they could diminish the trouble by increasing the focal length of the telescope, and thus making the image larger. An object glass, say, of 5 inches diameter, with focal length of 60 feet, would give no more confused image than the same object glass with a focal length of 6 feet. The image formed by the first would be ten times as large as that formed by the second, so that a low power of eye lens could be used, and hence the confused fringes produced the less disturbing effect with a given eye lens, the greater the focal length of the object glass. In this way Huyghens, Cassini, Hevelius, Bianchini, and other astronomers of the 17th century were able to obtain quite high magnifying powers. These astronomers made telescopes of 100 to 150 feet in focal length, and one man finished an object glass whose focal length was 600 feet.

Cassini mounted the objective on the top of a long pole free to move, while the eye piece was moved along near the ground until the object glass and eye lens were brought into line with the star to be observed. The tube of the telescope was dispensed with. Hevelius connected his object glass and eye piece by a long pole. Newton, in his treatise on optics, declared that the improvement of the refracting telescope was "desperate," and he turned his attention to reflecting telescopes. But an English optician named Dolland, about the middle of the 18th century, discovered a remedy. He found that by a combination of lenses of crown and of flint glass he could obtain an almost colorless image at the focus. This, indeed, was a grand victory, and at once enabled the opticians to construct telescopes of less length. They could now put more of the magnifying power in the eye piece, and have a telescope of such a length as could be comfortably handled. Telescopes made of such a combination of lenses as we have alluded to are called "achromatic." As larger and more perfect achromatic telescopes were made, a new source of aberration was discovered, no practical method of correcting which is yet known. It arises from the fact that flint glass, as compared with crown, spreads out the blue end of the spectrum more than the red end. The consequence is that two lenses cannot be made so as to entirely get rid of the color. "In a small instrument the defect is hardly noticeable, the only drawback being that a bright star or other object is seen surrounded by a blue or violet ring, formed by the indigo rays thrown out by the flint glass. If the eye piece is pushed in so that the star is seen, not as a point, but as a small disk, the center of this disk will be green or yellow, while the border will be reddish purple. But in the immense refractors of two feet aperture and upward, this 'secondary aberration,' as it is called, constitutes the most serious optical defect." Some think that no art can cure this defect. Many methods have been tried, all without much practical value. The defect may be lessened in the same way that the astronomers of the 17th century lessened the effect of "chromatic aberration"—viz., by lengthening the telescope. But the lenses of the 17th century were very small and light, compared with the large lenses now made. And it would be very difficult to mount rigidly a telescope 100 feet long, carrying one of the large modern lenses. Newcomb considers that, in the great refractors of recent times, the limit of optical power for such instruments has been very nearly attained.

Many of the telescopes of the older astronomers had object glasses (of crown glass only) of from ½ an inch to 1 inch in diameter. Some were larger. After Dolland made his discovery, the great difficulty experienced in obtaining disks of flint glass of the required degree of purity prevented the making of any large telescopes till the beginning of this century, when Guinand discovered a process of making large disks of glass free from air bubbles and striæ, and of equal density throughout. Most of my audience understand that the object glass of a refracting telescope is the "vital part, the construction of which involves the greatest difficulty." Given the object glass, and the rest of the telescope can be quite easily made. And in the making of the object glass there are two perfectly distinct processes. First, there are the beautifully clear disks of crown and of flint glass to be obtained. This is the work of the glass maker. And then these disks have to be ground and polished, so as to form perfect lenses which will give uncolored images and bring all the rays of light to one focus. This is the task of the optician. Both require extraordinary skill. Few men have it.

About the beginning of this century the "English Board of Longitude" offered a considerable reward for bringing the art of making flint glass for optical purposes to the requisite perfection; but it led to no important discoveries. The Academy of Sciences of Paris offered prizes in vain for this object, and it remained for a man, not distinguished by education nor a glass maker by trade, M. Guinand, of Switzerland, to have the honor of arriving at the solution of the difficulties.

Pierre Louis Guinand was one of those geniuses who seem to have great intuition and immense perseverance. He is said to have had no knowledge of optics, yet when quite young he constructed a small telescope equal to the best of his time. He soon turned his attention to producing glass disks of the requisite purity for making large telescopes. "He obtained some flint glass from England, but this was not always perfectly pure. He melted it anew, but did not obtain satisfactory glass." He then erected an establishment in which he constructed with his own hands a very large furnace, and commenced the manufacture of glass; and finally succeeded in obtaining pieces large enough for telescopes. He afterward discovered a method of softening pieces of perfectly pure glass for the purpose of giving them the form of a disk.

In 1805 he was employed by Utzschneider to assist in making object glasses at the celebrated optical establishment near Munich. Here he worked with Fraunhofer, but in a subordinate capacity. He had sold his secret with his service. After remaining here some nine years he returned home, drawing a pension from the Munich establishment so long as he did not reveal the secret or himself make object glasses.

He could not long resist the temptation, and soon gave up the pension to undertake the manufacture of larger disks than any he had previously made. In 1823 he produced a disk 18 inches in diameter. In 1824 he exhibited at the exposition in Paris a grand achromatic object glass which excited the admiration of the king, and Guinand was invited to come to Paris to live. He however, was in feeble health and old. He died in 1825 at the advanced age of nearly 80 years. Many think that Fraunhofer owed to Guinand much of his fame gained in making large object glasses.

After the death of Guinand, his widow and one of his sons set up works in Switzerland. The other son was introduced to Bontemps of Paris. They succeeded in producing good flint glass in disks of from 12 to 14 inches in diameter. In 1848 Bontemps accepted an invitation to unite with Messrs. Chance Bros. & Co., of Birmingham, England, in their efforts to improve the quality of glass.

They have succeeded in producing some very large disks, notably the ones for the Newall telescope of 25 inches, and also the disks for the great Washington telescope of 26 inches diameter. The establishment of Guinand at Paris is now conducted by Feil, a grandson of P. L. Guinand. Feil made the disks for the great Austrian refractor, 27 inches in diameter. He also made the disks for the Princeton telescope, and furnished the disks for the great Russian telescope of 30 inches diameter, and those of 36 inches for the Lick observatory of California.

The process of making these large disks seems to be well understood by Messrs. Chance and Feil, so that the only difficulty in getting the large disks is the long delay. The Russian disks were received by the opticians (the Clarks), who do the polishing, in about two years after being ordered.

The flint disk for the Lick telescope was ready in about one year, and the crown was nearly ready in nine months after, but was broken in the handling. Newcomb thinks that the secret of the manufacture consists principally in the constant stirring of the molten glass during the process of making.

The reason why the glass makers require so long a time to make the large disks may be understood from the following account:

"As optical glass is now made, the material is constantly stirred with an iron rod during all the time it is melting in the furnace, and after it has begun to cool, until it becomes so stiff that the stirring has to cease. It is then placed, pot and all, in the annealing furnace, where it is kept nearly at a melting heat for three weeks or more, according to the size of the pot. When the furnace has cooled off the glass is taken out, and the pot is broken from around it, leaving only the central mass of glass. Having such a mass, there is no trouble in breaking it up into pieces of all desirable purity, and sufficiently large for moderate sized telescopes. But when a great telescope of two feet aperture or upward is to be constructed, very delicate and laborious operations have to be undertaken. The outside of the glass has first to be chipped off, because it is filled with impurities from the material of the pot itself. But this is not all. Veins of unequal density are always found extending through the interior of the mass, no way of avoiding them having yet been discovered. They are supposed to arise from the materials of the pot and stirring rod, which become mixed in with the glass in consequence of the intense heat to which all are subjected. These veins must, so far as possible, be ground or chipped out with the greatest care. The glass is then melted again, pressed into a flat disk, and once more put into the annealing oven. In fact, the operation of annealing must be repeated every time the glass is melted." Annealing consumes two months each time for the large disks. "When cooled it is again examined for veins, of which great numbers are sure to be found. The problem now is to remove these by cutting and grinding without either breaking the glass in two or cutting a hole through it. If the parts of the glass are once separated, they can never be joined without producing a bad scar at the point of the junction. So long, however, as the surface is unbroken, the interior parts of the glass can be changed in form to any extent. Having ground out the veins as far as possible, the glass is to be again melted and moulded into proper shape. In this mould great care must be taken to have no folding of the surface. Imagining the latter to be a sort of skin inclosing the melted glass inside, it must be raised up wherever the glass is thinnest, and the latter allowed to slowly run together beneath it.

"If the disk is of flint, all the veins must be ground out on the first or second trial, because after two or three mouldings the glass will lose its transparency. A crown disk may, however, be melted a number of times without serious injury. In many cases—perhaps the majority—the artisan finds that after all his months of labor he cannot perfectly clear his glass of the noxious veins, and he has to break it up into smaller pieces. When he finally succeeds, the disk has the form of a thin grindstone two feet or upward in diameter, according to the size of the telescope to be made, and from two to three inches in thickness. The glass is then ready for the optician.

"The first process to be performed by the optician is to grind the glass into the shape of a lens with perfectly spherical surfaces. The convex surface must be ground in a saucer-shaped tool of corresponding form. It is impossible to make a tool perfectly spherical in the first place, but success may be secured on the geometrical principle that two surfaces cannot fit each other in all positions unless both are perfectly spherical. The tool of the optician is a very simple affair, being nothing more than a plate of iron somewhat larger, perhaps a fourth, than the lens to be ground to the corresponding curvature. In order to insure its changing to fit the glass, it is covered on the interior with a coating of pitch from an eighth to a quarter of an inch thick. This material is admirably adapted to the purpose, because it gives way certainly, though very slowly, to the pressure of the glass. In order that it may have room to change its form, grooves are cut through it in both directions, so as to leave it in the form of squares, like those on a chess board.

"It is then sprinkled over with rouge moistened with water and gently warmed. The roughly ground lens is then placed upon it, and moved from side to side. The direction of the motion is slightly changed with every stroke, so that after a dozen or so of strokes the lines of motion will lie in every direction on the tool. This change of direction is mostly readily and easily effected by the operator slowly walking around as he polishes, at the same time the lens is to be slowly turned around, either in the opposite direction or more rapidly yet in the same direction, so that the strokes of the polisher shall cross the lens in all directions. This double motion insures every part of the lens coming into contact with every part of the polisher, and moving over it in every direction. Then whatever parts either of the lens or of the polisher may be too high to form a spherical surface will be gradually worn down, thus securing the perfect sphericity of both.

"When the polishing is done by machinery, which is the custom in Europe, with large lenses, the polisher is slid back and forth over the lens by means of a crank attached to a revolving wheel. The polisher is at the same time slowly revolved around a pivot at its center, which pivot the crank works into, and the glass below it is slowly turned in the opposite direction. Thus the same effect is produced as in the other system. Those who practice this method claim that by thus using machinery the conditions of a uniform polish for every part of the surface can be more perfectly fulfilled than by a hand motion. The results, however, do not support this view. No European optician will claim to do better work than the American firm of Alvan Clark & Sons in producing uniformly good object glasses, and this firm always does the work by hand, moving the glass over the polisher, and not the polisher over the glass."

Little imperfections are sure to exist after the first polishing. It is in the nice correction of these that the great skill of the optician is shown and much time is consumed.

The American firm of Alvan Clark & Sons enjoys the reputation of being the best opticians in the world for polishing large lenses.

When the Russian government decided to construct a telescope that would surpass in size the great Washington telescope of 26 inches diameter of object glass, Otto Struve, the director of the Imperial observatory, was commissioned to make an examination of the optical workshops of the world to discover where the best object glass makers could be found. After he had made a thorough examination in Europe and in this country, he gave the contract to the firm of Alvan Clark & Sons. This great object glass, 30 inches in diameter, is now completed. When the Russian glass was contracted for, the trustees of the Lick observatory in California ordered an object glass of 36 inches aperture—so that we still have in the United States the largest refracting telescope in the world.

I have dwelt upon the object glass of a great refracting telescope because of its vital importance. We will have some explanations to make in regard to mountings, etc., when at the close of the lecture we throw on the screen several pictures to illustrate our subject.

As we have previously stated, Isaac Newton, in the latter part of the 17th century, believed that there was no remedy for the defects in the refracting telescopes as then made, and he turned his attention to reflecting telescopes. Now, it is well known that when parallel rays of light fall on a concave mirror, they will all be reflected back to a focus, there forming an image of the object from which the rays emanate. The form of this concave mirror must be such that a section of it cut by a plane parallel to the length of the telescope will be a parabola. The image formed will be made up of *all* the rays—there will be no such thing as chromatic aberration. Thus if a mirror could be made and would continue of the true parabolic shape, the great and desperate difficulty in the way of improving the telescopes might be removed.

In the time of Newton, the reflecting telescopes, however, did not excel the long refracting telescopes. Even after Dolland's discovery, the great difficulty met with in obtaining pure glass made the earlier short achromatic telescopes not much better than the long instruments. But in the latter part of the 18th century a genius arose who solved the problem of the construction of large mirrors. History tells us that "William Herschel, in 1766, was a church organist and teacher of music, of high repute in Bath. He spent what little leisure he had in the study of mathematics, astronomy, and optics. By accident a Gregorian reflector two feet long fell into his hands, and turning it to the heavens, he was so enraptured with the views presented to him that he sent to London to see if he could not purchase one of greater power. The price named was far above his means. He resolved, then, to make one for himself. After many experiments with metallic alloys, to learn which would reflect most light, and many efforts to find the best way of polishing his mirror, and giving it a parabolic form, he produced a five foot long (Newtonian) reflector, which revealed to him a number of interesting celestial phenomena, though, of course, nothing that was not already known."

He determined, then, to make the largest telescope that could be made, and after many failures he produced a telescope having a mirror two feet in diameter and 20 feet long. At this time, 1781, he discovered the planet Uranus. His fame coming to the ears of the king, George III., that monarch gave him a pension of £220, that he might devote his life to the study of the heavens. He now accomplished his greatest work by making a reflector 4 feet in diameter and 40 feet long. With this he discovered two new moons of Saturn.

It was not until 1842 that another great step was taken in the direction of increasing the power of the reflecting telescopes. Then the Earl of Rosse, of Parsonstown, Ireland, constructed (using steam machinery for grinding and polishing) a great mirror, six feet in diameter, the tube being fifty-four feet in length. The telescope has not done as much work as was expected, owing to the bad climate of the region where it is placed. It has been said that there are only a few hours in the year when the telescope can be used with its greatest efficiency.

Since 1842 a considerable number of large reflecting telescopes have been made. But as a general rule (though silvered glass mirrors have been substituted for those of metallic alloy), the reflectors have not

given as much satisfaction as was to be expected. The large ones are more difficult to handle; the mirror tarnishes readily, and has to be frequently resilvered, and the alternations of heat and cold and of flexure produce a distortion of the curve which makes the mirror focus badly. These difficulties are so troublesome that refractors are usually preferred.

The following table gives the location, character, and aperture of the great telescopes of the world.

SIZE OF PRINCIPAL TELESCOPES IN THE WORLD.

Refractors.

Owner and Location.	Constructed by	Aperture.	Remarks.
Lick Observatory, Cal.,	A. Clark & Sons.	36 in.	
Pulkova, Russia,	A. Clark & Sons,	30 "	Finished in May, 1883.
Yale College,	A. Clark & Sons,	28 "	Constructing.
Littrow, Vienna,	Grubb,	27 "	
University of Virginia,	A. Clark & Sons,	26 "	
Washington Naval Observatory,	A. Clark & Sons,	26 "	
Gateshead, England,	Cooke,	25 "	
Princeton, N. J.,	A. Clark & Sons,	23 "	
Buckingham, London, Eng.,	Buckingham,	21 "	
University of Chicago,	A. Clark & Sons,	18·5 "	
Strasbourg,	Merz,	18 "	
Private Observatory, Buffalo,	Fitz.	18 "	
Warner Observatory, Rochester,	Clark & Sons,	16 "	
Washburne Observatory, Madison, Wis.,	A. Clark & Sons,	15·50 "	
Harvard College,	Merz,	14·95 "	
Pulkova, Russia,	Merz,	14·93 "	
Lord Lindsay, Dun Echt,	Grubb,	15 "	
Royal society, near Lond.,	Grubb,	15 "	
Downsede College, Bath,		14·5 "	Destroyed by fire in 1867.
Markree Castle,		14 "	
Oom, Lisbon,	Merz,	14 Fr. in.	
C. H. F. Peters, Clinton,	Spencer,	13·5 in.	
Boss, Albany,	Fitz.	13 "	
Columbia College Observ'y,	Rutherfurd & Fitz,	13 "	Photographic lens attachable. Presented to Columbia College by Mr. Rutherfurd in Dec. 1883.
Allegheny Observatory, Pa.	Fitz,	13 "	
Ann Arbor, Mich.,	Fitz,	12·5 "	
Christie, Greenwich,	Merz & Simms,	12·25 "	
Vassar College,	Fitz, reworked by Clark,	12·5 "	
Pritchard, Oxford,	Grubb,	12·25 "	
Glasgow, U. S.,	A. Clark & Sons,	12·25 "	
Paris,	Secretan & Eichens,	12 Fr. in.	
Littrow, Vienna,	A. Clark & Sons,	12 in.	
Adams, Cambridge,	Cauchoix,	12 "	
White, Brooklyn, N. Y.	Fitz,	12 "	
Ball, Dublin,	Cauchoix,	12 " (?)	
H. Draper, Jr., New York,	A. Clark & Sons,	11 "	
Main, Oxford,	Chauchoix,	12 " (?)	
Pritchard, Oxford,	Grubb,	12 "	
Cincinnati,	Merz,	11·5 "	
Bothkamp, Germany,	Schroeder,	11·7 "	
Cordova, S. A.,	Fitz,	11·2 "	
Munich, Germany,	Merz,	11 "	
Copenhagen, Denmark,	Merz,	11 "	
Middletown, Conn.,	Clark & Sons,	11 "	
And many others.			

Reflectors.

Owner and Location.	Constructed by	Aperture.	Remarks.
Lord Rosse, Birr Castle,	Rosse,	6 ft.	
William Herschel, Slough,	W. Herschel,	4 "	Out of use.
Lassell, Liverpool, etc.,	Lassell,	4 "	Since destroyed.
Ellery, Melbourne,	Grubb,	4 "	
Paris,	Martin, Eichens,	4 "	Silvered glass.
Lord Rosse, Birr Castle,	Rosse,	36 in.	Silvered glass.
Common, England,		36 "	
Tisserand, Toulouse,	Foucault,	32·4 "	
Stephan, Marseilles,	Foucault, Eichens,	31·5 "	
H. Draper, nr. N. Y.	H. Draper,	28 "	Silvered glass.
Lassell, Maidenhead,	Lassell,	24 "	Metal.
W. & H. Herschel, Slough, and C. G. H.,	W. & J. Herschel,	18 "	Several mirrors.
H. Draper, nr. N. Y.,	H. Draper,	15 "	
M'Lean, Tunbridge Wells,	With & Browning,	15 "	
Pritchard, Oxford,	De la Rue,	13 "	
Worthington & Baxendell, Manchester,	With & Browning (?)	13 "	
And many others.			

NOTE.—The object glass of the Lick equatorial is to cost....	$52,000 00
Photographic lens of crown glass.	13,000 00
Mounting of telescope....	42,000 00
Dome and machinery....	56,800 00
Total....	$163,800 00

Mr. A. Swazey, of Cleveland, furnishes the following data in regard to the great Lick telescope:

Focal length 56 feet.

Length of polar axis 12 feet.

Diameter of polar axis 12 inches, with a cylindrical hole 5 inches in diameter.

Declination axis: length, 12 feet; diameter, 10 inches, with 5 inch hole.

Largest circles 3 feet in diameter.

The tube of steel will weigh about 3 tons. The tube and all the movable parts (polar axis, etc.) will weigh 12 tons. The "head" will weigh 3 tons and the pier 10 tons, making a total of 25 tons.

The lenses with their cell weigh about 700 pounds.—*Transactions of the N. Y. Academy of Sciences.*

READING OF DIAL INSTRUMENTS.

THERE is in existence a large number of dial instruments, such as galvanometers, compasses, in which the needle is at some distance from the scale of graduation. It not unfrequently happens that the reading is falsified several degrees through the eye not being in the correct position.

To obviate this serious defect, some makers are in the habit of placing under the needle a flat mirror parallel to the dial. Then the eye is in the correct position when the reflection is hidden by the needle.

When the instruments are not furnished with this excellent arrangement, it is still possible to obtain as accurate reading in a simple manner.

The greater number of these instruments have their dial plate covered with a flat glass which is parallel to it. It is sufficient, writes M. F. Drouin in a late issue of *La Lumière Electrique*, to apply to this glass in front of the needle a parallelopiped of plate or flint glass. In virtue of the elementary laws of refraction, the needle will seem to be broken whenever the luminous ray is not normal to the dial. The accuracy of the reading will depend on the thickness of the parallelopiped employed.

Fig. 1 shows the appearance of the needle when the eye is in the correct position, Fig. 2 when it is not.

It is evident that the same method may be applied to barometers, thermometers, etc., and, in short, to all

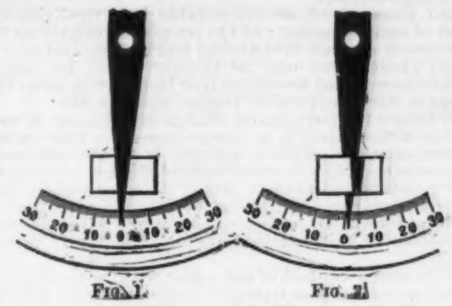


FIG. 1. FIG. 2.

instruments in which the index is at a certain distance from the scale of graduation.—*Elec. Review.*

AN IMPROVED ALTAZIMUTH MOUNTING.

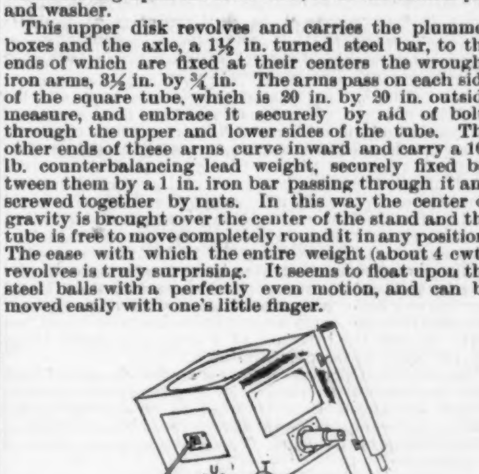
HAVING conjointly with my brother purchased of Mr. With a glass speculum, 15 in. diameter and of 6 ft. 5 in. focus, which he had reserved for his own use, together with a square framed wooden tube and wooden cell which he had prepared for it, we decided to mount it as an altazimuth in the most efficient manner, and to build an observatory for it at my residence at Oakfield, near Southampton.

After consideration of the usual methods of such mounting, I resolved to attempt a novel plan, with the view of reducing the amount of friction, obtaining greater steadiness and ease of motion, and so mounting the tube as to occupy the smallest possible space in its movements.

The plan I devised and carried out has exceeded my expectations and is a practical success, and as it may be of some interest to others possessing large specula, I venture to give some description of this "Oakfield" method of mounting an altazimuth.

The support is simply a 10 in. cast iron water pipe, 9 ft. long, sunk into the ground about half way, flange upward, and secured by a mass of concrete cement. This forms an absolutely rigid stand; it carries a cast iron disk, 1½ in. thick and 17 in. diameter, securely fixed to the pipe by clamps and screws inside the flange. The edge of this fixed disk is turned to receive a friction wheel. A V shaped groove is turned on the upper surface, in which 100 steel balls ⅜ diameter are placed in a continuous roll, to carry the upper disk. A central steel pin with washer and nut is secured in the center of the fixed disk, and keeps the upper revolving disk in its position. The upper disk is also of cast iron, 1¼ in. thick and 17 in. diameter, turned on the under side, where resting upon the steel balls, to fit the central pin and washer.

This upper disk revolves and carries the plummer boxes and the axle, a 1½ in. turned steel bar, to the ends of which are fixed at their centers the wrought iron arms, 3½ in. by ¾ in. The arms pass on each side of the square tube, which is 20 in. by 20 in. outside measure, and embrace it securely by aid of bolts through the upper and lower sides of the tube. The other ends of these arms curve inward and carry a 166 lb. counterbalancing lead weight, securely fixed between them by a 1 in. iron bar passing through it and screwed together by nuts. In this way the center of gravity is brought over the center of the stand and the tube is free to move completely round it in any position. The ease with which the entire weight (about 4 cwt.) revolves is truly surprising. It seems to float upon the steel balls with a perfectly even motion, and can be moved easily with one's little finger.



A, iron pipe stand; B, fixed disk, with turned edge; C, screws to fix B to A; D, upper revolving disk; E, plummer boxes carrying axle; F, axle; G, arms; H, framed and paneled wooden tube; I, bolts and nuts through tube and arms; K, 166 lb. lead weight; L, bolt through weight fixed with screws and nuts; M, wrought iron arm; N, altitude rod; O, cast iron box carrying friction wheel; P, Hooke's joint; Q, ¾ in. tube; R, ½ in. square rod; S, toothed wheel at top of R; T, wheel spindle and worm to drive S; U, hinged brass box carrying S and T; V, clamp; W, hinged door to get at mirror.

This upper revolving disk also carries an arm of wrought T iron, with the usual altitude rod of Browning's pattern. The azimuth motion is, I think, novel, and is excellent in practice. It comprises a steel friction wheel or roller, 1 in. diameter, carried (the axis being in a vertical position) by a cast iron box moving horizontally in slide bearings attached to the upper disk and rolling against the turned edge of the lower one. The exact pressure for the friction required is obtained and regulated by a spiral spring and screw drawing the box and roller inward against the edge of the fixed lower disk. Motion is conveyed to this friction roller by gearing, thus: a Hooke's joint is attached to the head of the roller and to a ¾ in. steel tube rod inside of which slides a ½ in. square iron rod having a toothed wheel at the upper end driven by a wormed screw, with spindle and wheel handle, carried by a brass box hinged to the under side of the tube within easy reach of the eye end. The hinge, sliding rod, and the Hooke's joint allow for every variation of length and angle.

The ½ in. square rod and the ¾ in. tube are connected by a gun metal cap with internal screw clamp, so as to be free for the coarse motion, and are easily clamped together, and so fixed when the slow motion is required while observing.

The tube being thus carried "saddle" fashion *centrally over the support* effects a great saving of space, and I have been able to construct the observatory only 10 ft. long by 8 ft. in width and 7 ft. 6 in. in height. The entire roof, which is flat, is carried by wheels rolling upon iron rails at each side, extending on the north side to carry the roof when rolled off. The building is of wood, the roof being a light wood frame covered with corrugated galvanized iron, and that covered with a mat of heath to protect it from the sun's heat.

At the south end is a window, extending the full width of the building, and 2 ft. in height, hinged to fall outward, and on each side the southern half has shutters also fitted to fall outward when the roof is off; these are balanced by weights. By these means every desired part of the sky can be reached, and though protection is afforded to the observer, yet, the roof being open, the instrument is practically in the open air, a matter of importance in using reflectors.

The peculiarity of this "Oakfield" form of altazimuth mounting may be summed up thus: First, the entire moving weight is carried upon *ball bearings*. Secondly, the azimuth motion is driven by a *friction roller*, instead of by the usual fine screws.—*T. A. Skelton (Major), in English Mechanic.*

THE CHEMISTRY OF SUBSTANCES TAKING PART IN PUTREFACTION AND ANTISEPSIS.*

By JOHN M. THOMSON, F.R.S.E., Sec. C.S., Demonstrator of Chemistry, King's College, London.

I.

As the employment of agents, chemical and otherwise, for the preservation of natural products and for the prevention in them of decay, as well as the use of chemical substances as counteracting agents to the spread of disease, have become so general among the public in the last few years, I thought that the present course which the council of the society have done me the honor to ask me to give might be usefully occupied with a description of the more important properties of some of these substances, and with the general bearings of some of the changes which lead to their production.

I am well aware that in doing this I shall not be able to bring before those who may already be practically engaged in such questions anything that is particularly new, but my wish and endeavor will be to put before you the material suggested by the syllabus in a manner suitable to a general audience, such as the members of the society represent.

As the consideration of fermentation in its relation to industrial processes has been so often and ably given in this room, it is not my intention in this course to deal with its special changes. My object rather is to deal with the formation and properties of those substances which are produced in the changes which are grouped together under the name of putrefaction, and which it is our special object to check or prevent by the use of agents which are termed disinfectants.

Before passing, however, to such a special consideration, it is necessary that we glance at certain general questions as to the supposed origin of these changes, and the reactions taking place when such changes occur, so that we may the better understand the properties of the bodies produced in them.

It is my intention, then, to divide the consideration of the matter indicated by the title as follows:

First, to consider the general questions affecting the changes taking place during certain processes of fermentation and putrefaction.

Secondly, to pass to the special properties of the more important chemical substances produced in such changes, dividing them as far as possible into groups.

In the third place, to deal with general questions relating to the retardation or prevention of putrefaction, more especially with chemical methods adopted for such prevention.

And finally, to consider the chemical properties of the more common and important substances employed as antiseptics.

In the popular sense, the processes of fermentation and putrefaction are regarded as distinct, and the term fermentation is applied only to such changes as are carried out with the production of no offensive odor; putrefaction, to those still further changes which occur more marked perhaps in animal than in vegetable substances, and which are accompanied by distinct putrid odors. Thus the change which produces alcohol from sugar is regarded as fermentation, while the production of sulphur compounds, etc., in the decaying egg or some other animal body is marked as putrefaction.

The chemical operation of both, however, is of the same kind, consisting in the resolution of complex substances into simpler forms; the complex organic substances becoming broken up into simpler ones, these in their turn becoming converted into still simpler forms, and finally into so-called inorganic substances, as carbon dioxide, ammonia, hydric phosphide,

* Three lectures before the Society of Arts, London, 1887.—*From the Journal of the Society.*

water, hydric sulphide, and sometimes even into the elementary gases, hydrogen and nitrogen.

Under ordinary circumstances these changes are generalized, as fermentation and putrefaction, which take place at the same time as the development of living plants or organisms; and the presence of some or all of these is one of the conditions necessary for the production of such changes.

We shall see, however, later on, that certain unorganized substances may be obtained which are capable of exciting and carrying on many of these changes; but as none of these substances has as yet been synthesized from simple materials, and all are dependent for their formation, so far as we at present know, upon what are called "life processes," the first remark is true for all fermentation and putrefaction taking place around us in nature, and not produced by any direct or special experiment of our own.

The change taking place during ordinary fermentation is best seen by the formation of carbonic acid gas or carbon dioxide, which is evolved during the conversion of sugar into alcohol by the action of the yeast ferment. It may be shown experimentally by placing the yeast and sugar in a glass globe which has a delivery tube attached to it, by means of which the CO_2 evolved may be collected in a cylinder over water. This change, as we shall see later on, takes place more quickly on the application of a gentle heat, but this must not be to such an extent as to destroy the yeast cell.

Although the sugars present the best known instances of bodies liable to ferment, the starches, dextrin, etc., may also be made to undergo a similar change; it will be seen, however, that this change entails the conversion of the starch first into one of the varieties of sugar, viz., glucose:

$$\underset{\text{Dextrin.}}{C_6H_{10}O_5}+H_2O=\underset{\text{Glucose.}}{C_6H_{12}O_6}.$$

$$C_6H_{12}O_6 = \underset{\text{Alcohol.}}{2(C_2H_6O)}+2CO_2.$$

The chemical properties of starch and sugar are very different, although the one may be converted into the other. This is readily seen by adding a solution of iodine to a large volume of starch solution, when we at once get a brilliant blue color; extremely minute quantities of starch sufficing to show the reaction.

Sugar, on the other hand, shows no such tendency, but on its part may be recognized by its reducing power on certain salts of copper, one of which, the tartrate (Fehling's solution), may be used. This test can also be employed to indicate the difference between the two varieties of sugar which are commonly dealt with, viz., the glucose or grape sugar and the cane sugar. On adding the copper solution to the solution of glucose, and warming, we have an immediate deposition of copper suboxide. With the cane sugar, however, it requires boiling for some considerable time before the precipitate is obtained; the reason of this being, as many of you know, that the cane must be converted into grape sugar before the reaction takes place.

The assimilation of water by starch, with its conversion into glucose, can be readily effected by boiling for a short time with water and an acid, when the nature of the starch is entirely lost, and the presence of sugar made apparent. You see this now going on before you, and, on dividing and cooling the solution, one portion shows us nothing by our iodine reaction; while the other portion shows abundant evidence of sugar by the copper reaction.

Whatever may be the particular change which ultimately takes place during the process of different fermentations, it is now established that such changes will not take place under ordinary circumstances, unless originated by the entrance into the fermenting solution of some medium carrying the particular germ which starts each particular change.

From the earliest times, it was supposed that the lower forms of life were evolved from dead matter, and that substances like flesh and cheese were converted by putrefaction into living animalcules. This view was first proved to be erroneous by the experiments of Redi, in 1638, who showed that when the material liable to decay was covered with gauze, the cause of the putrefying changes was entirely removed.

Further light was thrown on the determining cause of those changes by the experiments of Schroeder and Dusch, who demonstrated the fact that air when filtered through cotton wool, before coming in contact with the organic matter, had entirely lost its active power. Later, the experiments of Schwann showed that other preventive causes might be employed, such as the heating of the air, or its passage through certain corrosive chemicals, as potash or sulphuric acid.

Viewing the existing cause of these changes in the most general manner, it is now quite established, from the work of Pasteur, Tyndall, and many others, that each form of fermentation or putrefaction has its own specific germ or primal cause, and that if this be prevented from coming in contact with the putrescible liquid, no change will take place.

It is somewhat difficult to exhibit quickly to an audience any change arising from the introduction of such a germ, but this may, to a certain extent, be done by taking advantage of other phenomena with which we are acquainted, and which show us most distinctly the presence of such active bodies in the air.

If we prepare a solution of sodium sulphate in a state of so-called supersaturation, and allow it to cool, covered with cotton wool, the salt will remain in solution, although disturbed by many causes, until there enters the flask a particle of the substance itself, when crystallization, as you see, at once begins, and finally passes through the whole of the fluid.

Should, however, the air be filtered through cotton wool, breathed through the lungs, or passed through a red hot tube before entering the solution, the active nature of the nucleus, or germ, is at once destroyed. This may be seen in the arrangement before you, where we pass a current of heated air through the flask containing the supersaturated solution without any action taking place. On removing the heated tube, however, and replacing it by a cold one, and again drawing air through the flask, after a short delay crystallization is produced.

The question of the special nature and action of the living organism capable of starting such changes is one which belongs to the province of the biologist, and must be treated of specially by him. It is a department of the subject quite outside the scope of our present considerations.

The changes which we regard as producing fermentation and ultimately putrefaction may be divided into two large classes:

(*a*.) Those which are inseparable from the living action of some organism; as the conversion of glucose by the action of yeast into alcohol and carbon dioxide.

(*b*.) Those which may be brought about by means of an unorganized substance free from germs, as in the cases of diastase, ptyalin, tripsin, steapsin, etc.

Whether the fermentable change may belong to one group or the other, it is always necessary that an exciting cause be present, whether it be the nitrogenous substance in an active state of change as yeast, or the substance as ptyalin, which itself apparently unaltered, produces a change in the substance to which it is introduced. In either case contact with the fermentable or putrescible liquid is apparently necessary.

This actual contact of the agent with the substance acted upon has been strongly insisted upon by Mitscherlich, who carried out an experiment showing that if the yeast ferment be separated from a portion of the sugar solution, the production of alcohol will only take place in that portion in which the ferment comes in contact with the sugar solution. For this purpose a glass tube, the bottom of which was covered with a piece of fine filter paper, was partially immersed in a solution of sugar. The solution rapidly passes through the paper and fills the tube to the level of the liquid in the outer vessel. A small quantity of yeast was then added to the solution in the inner tube; this, after a short time, commenced fermenting, with the production of carbon dioxide.

There was no sign, however, of fermentation in the outer vessel, the bibulous paper preventing the passage of the yeast cells. It is well to note, however, that there is a certain amount of evidence of changes producing substances other than alcohol in the outer vessel containing the sugar.

With regard to this question of actual contact, it seems most probable at the present time that, where the action cannot be separated from the life processes of the living organism, such contact as we have seen in the flask is absolutely necessary. In these classes of fermentation, however, in which an unorganized substance is capable of producing the change, the presence of paper, or material through which an interchange of fluids may take place, may not interfere with the action, although it may cause delay.

Let us now consider more closely the second kind of fermentation which I have mentioned, namely, the "changes produced by substances other than living organisms."

This may be seen in the formation of what is known as "oil of bitter almonds," which is obtained by mixing an emulsion of sweet almonds with one of bitter almonds. The first of these contains a substance known as emulsine, while the second a complicated substance termed amygdaline. When the emulsine is dissolved in cold water, and mixed with a solution of amygdaline, the latter undergoes change, the oil of bitter almonds being formed in abundance. If the solution of emulsine be boiled, however, it is incapable of forming the essence. The action probably taking place in this case of fermentation may be presented as—

$$\underset{\text{Amygdaline.}}{2(C_{20}H_{27}NO_{11})}=$$

$$\underset{\text{Bitter Almond Oil.}}{4(C_7H_6O)}+2HCN+C_6H_{14}O_7+4CH_2O_2+3H_2O;$$

or according to some—

$$C_{20}H_{27}NO_{11}+2H_2O=$$

$$2C_6H_{12}O_6+\underset{\text{Bitter Almond Oil.}}{C_7H_6O.\ HCN}.$$

The change occurring here is best seen experimentally by testing the original substances with potash and ferrous sulphate, when no change in color takes place. On applying the same test to the fermented liquor, we have at once the presence of a cyanide evinced to us by the deep blue color produced.

More interest perhaps attaches to the change of urea into ammonium carbonate by a putrefactive action, which was at one time believed to be excited by the mucus, a decomposable substance resembling albumen, and existing in the urine. The conversion may be thus expressed—

$$\underset{\text{Urea.}}{CH_4N_2O}+2H_2O=(NH_4)_2CO_3.$$

For a long time this change at the ordinary temperature was considered to be inseparable from the action of living organisms, but the recent experiments of Mr. Sheridan Lea have shown that it is possible to extract from a solution of urea in an active state of change an unorganized substance free from living organisms, but which will excite the change in a fresh solution of urea, and which can be kept, with care, in a dry state for a considerable length of time.

Another instance of the same kind familiar to you all is the change produced in the curdling of milk by the formation of casein by means of rennet. Originally this was supposed to be inseparable from the immediate action of a living organism, but an extract may be obtained possessing all the powers of the rennet itself, although free from living organisms.

In all these latter actions the existing cause, although producing such great changes, is apparently itself unaltered, and seems to be capable, even when present in small quantities, of producing an almost unlimited amount of change. In the present state of our knowledge, considerable difficulty is experienced in explaining the apparent anomaly of a substance being unaffected itself and yet being the cause of change. An analogy which, although imperfect, may yet help us to form some idea of the nature of such a decomposition is to be found in actions such as that of metallic silver on hydrogen peroxide, a substance which may, for our present purpose, be regarded as a compound of water and oxygen. When silver in a fine state of division is thrown into the hydrogen peroxide, the latter is decomposed, evolving, as may be seen in this cylinder, large quantities of oxygen, but the silver itself remains absolutely unchanged.

From the various experiments which we have observed, it will at once become evident to you that the entrance of air or some other medium laden with the existing cause is necessary for fermentation and putrefaction, and that if the air on entering be thoroughly purified, no putrefactive change will take place. This, as we shall see later on, applies also to moisture, the absence of which is a certain condition for the prevention or retardation of putrefactive changes.

I have here on the lecture table a series of flasks containing putrescible liquids, these flasks having been carefully prepared either by plugging their necks with cotton wool or drawing out the neck and bending it in various ways, so that on entering the flask the air becomes purified or sterilized by depositing the existing germs in the cotton or in the bends of the tube. From the elaborate experiments of Pasteur and Tyndall, we have complete confirmation of the fact that pure air is in itself perfectly innocuous, and merely acts as a vehicle for the existing substance. One condition, however, of the greatest importance in carrying on the change after it has been excited is the temperature of the decomposing fluid, extremes of either heat or cold arresting the action. We shall have to consider this more fully at a later point in the course in dealing with the preservation of food from putrefaction, and I will, therefore, at present merely show you the effect of cold in arresting the fermentation of ordinary sugar.

For this purpose I take some of the liquid from our first experiment, which you see is in an active condition, evolving large quantities of carbon dioxide gas, and pouring some of this into a fresh flask containing some lumps of ice, we find that the evolution of the gas gradually fails, and finally ceases altogether.

From 0° to 20° C. fermentable changes gradually increase in intensity with the rise in temperature, becoming most active between 20° and 40°. On reaching 50°, however, the growth of the ferment appears to be arrested. The same result is obtained if the temperature sinks below 0° C.

Having now considered some of the more general questions relating to those changes which ultimately produce putrefactive decomposition, I think it may be of interest to classify shortly the more important fermentable changes to which we have been alluding.

The more common cases of fermentation which we may mention as bearing more directly on our subject are the following:

1. Alcoholic.
2. Acetic (fermentation with oxidation).
3. Lactic.
4. Butyric.
5. Ammoniacal.

There are, as you know, many other forms of fermentation, such as mucous, pectous, and gallous, but the special considerations of their changes lie outside the scope of the present course.

ALCOHOLIC FERMENTATION.

In this process we have the conversion of the juices of all sugar-containing plants, by reason of the glucose existing in this juice, into alcohol; this change, as is now established, taking place at a temperature somewhere between 20° and 25° C. The changes produced in the fermentation may be represented in the following equations:

$$1.\ \underset{\text{Cane Sugar.}}{C_{12}H_{22}O_{11}}+H_2O=\underset{\text{Glucose.}}{2(C_6H_{12}O_6)}.$$

$$2.\ C_6H_{12}O_6=2(C_2H_6O)+2CO_2.$$

ACETOUS FERMENTATION.

In this, the change which occurs is the result of oxidation, and the chemical process is one evidently taking place in two stages. In the first, the alcohol becomes converted into a substance termed aldehyde, as may be seen in the expression:

$$\underset{\text{Alcohol.}}{C_2H_6O}+O=\underset{\text{Aldehyde.}}{C_2H_4O}+H_2O;$$

while the second portion of the change is the further oxidation of this body into acetic acid—

$$C_2H_4O+O=\underset{\text{Acetic Acid.}}{C_2H_4O_2}.$$

To demonstrate such an oxidation to you, it is necessary to employ certain chemical means for the rapid oxidation of the alcohol, which may be done by bringing it in contact with potassium dichromate and hydrochloric acid, and distilling. On carrying out such a change and condensing the product, we find it yields reactions by which it may be identified. Thus on adding to the product of our distillation some silver nitrate and ammonia, and warming the mixture, we obtain the reduction of the silver salt and a fine deposit of metallic silver. The substance here formed, or aldehyde ammonia, as it is termed, is employed for the coating of the interior of large globes, etc., with metallic silver.

The aldehyde, however, in ordinary acetous fermentation never makes its appearance, as it at once, on its production, becomes converted into acetic acid—

$$C_2H_4O+O=C_2H_4O_2.$$

This further stage in the oxidation may be realized, not by using free oxygen, but by employing some method by which the oxygen may be brought into closer contact with the materials to be operated upon. This can be done by platinum black, and on the table you have an experiment in which you perceive that the alcohol is gradually being converted into acetic acid, and that the vapors filling the jar show a distinct acid reaction to the blue litmus paper placed round it. The platinum black, deprived of the air and oxygen between its particles during this reaction, becomes readily revivified on exposure to air, and a limited quantity of the platinum may, therefore, be employed to convert a large quantity of alcohol into acetic acid by means of the atmospheric oxygen. The properties of acetic acid thus formed are of considerable interest. Although generally met with as a liquid, it solidifies in its glacial condition, about 13° C., into beautiful, ice-like crystals, of which you have a specimen before you. On boiling the acid as I now do, it gives off a heavy vapor, which ignites on bringing a light to it, burning with a beautiful blue flame. In this combustion the acid is converted into carbon dioxide and water.

LACTIC AND BUTYRIC FERMENTATION.

The common occurrence of the souring of milk, which I have already referred to at an earlier part of

my lecture, is the result of a change in which we have the decomposition of milk sugar into lactic acid—

Sugar of Milk. Lactic Acid.

$$C_{12}H_{22}O_{11}H_2O = 4(C_3H_6O_3),$$

the milk sugar before passing into the form of lactic acid probably passing through that of glucose. In this case, however, the reaction ceases when the acidity of the fluid reaches a certain limit, and for any further change to take place, must be carried out in presence of chalk or sodium carbonate, which converts the lactic acid into calcium or sodium lactate, and allows the process to proceed to a further stage with the formation of calcium butyrate, thus:

Calcium Lactate.

$$2\{Ca(C_3H_5O_3)_2\} + H_2O =$$

Calcium Butyrate.

$$Ca(C_4H_7O_2)_2 + CaCo_3 + 3CO_2 + H_4.$$

Butyric acid is met with not only in rancid butter, but also in the juice of muscular flesh, and with some other acids, such as valerianic and caproic, appears to be present in the perspiration of the skin, and thus to cause one of the disagreeable odors found in very close rooms.

The chånges accompanying the refining of cheese are closely allied to butyric fermentation. This becomes apparent when we examine the composition of new and old Roquefort cheese. The refining of this particular cheese takes place only in one place, the air being there laden with the particular germs capable of producing this special change. The flavor of rancid butter differs from the high delicacy of the Roquefort cheese from the fact that in this latter the free butyric and other acids are neutralized by ammonia. Caseine being a highly nitrogenous substance, the nitrogen in the process of refining becomes converted into ammonia or some compound of it, while the carbon and hydrogen appear as a fat called oleine. This oleine oxidizes so as to form the fatty acids, but these, instead of being in the free state, as they are in rancid butter, are neutralized by the formation of ammonium salts.

Lactic acid may be recognized in combination by a violet color which it gives with soluble cobalt salts. The solution, on stirring, deposits small dark pink crystals of cobalt lactate.

Citric acid, found in many plants, is converted much in the same way as the lactic acid into acetic and butyric acids. Many of you may have noticed the peculiar smell of butyric acid in the citric acid imported into this country from Sicily. This is due to the calcium citrate undergoing a spontaneous decomposition of this nature, and it has been recommended to import the citric acid into this country as basic magnesium citrate, which apparently resists decomposition.

DIVISION OF THE MORE COMMON PRODUCTS ARISING IN PUTREFACTION.

The more common products arising from the changes we have examined, when they advance to the stage of putrefaction, may be roughly arranged in the following groups, commencing with those more complicated in their structure and advancing to those of the simplest nature:

Cadaveric alkaloids (Ptomaines).
Leucine. Tyrosine.

Amines.

Ethylamine.	Methylamine.
Propylamine.	Amylamine.
Butylamine.	

Fatty Acids.

Formic.	Butyric.
Acetic.	Caproic.
Propionic.	and
Lactic.	Valerianic.

Carbon dioxide.	Ammonia.	Nitrous acid (?).
Hydrogen sulphide.	Water.	Hydrogen.
Nitrogen.		

The so-called cadaveric alkaloids, or ptomaines, are supposed to exist and to be produced in animal bodies after death. The substances leucine and tyrosine arise from the decomposition of matter containing gelatine.

Of the amines, ethylamine, trimethylamine, and amylamine are found in putrefying animal substances, trimethylamine being also found in the roe of herrings and putrid urine. Methylamine, ethylamine, propylamine, butylamine, and amylamine are found among the products of the decomposition of bones.

These more complicated structures, after their first production, gradually undergo further decomposition, with the formation of carbon dioxide and water, those containing nitrogen yielding ammonia, and those containing sulphur, hydric sulphide as well.

ON A NEW METHOD OF EXAMINING BUTTER.

By Thomas T. P. Bruce Warren.

In making a quantitative examination of oleomargarine I found, after separating out the cotton seed oil, the residue exhausted with carbon disulphide contained cocoa nut oil and animal fat.

The oleomargarine was so entirely free from the smell and taste peculiar to cocoa nut oil that I feel inquisitive as to what could have been added to have so completely masked its smell and flavor; when separated from the cotton seed oil, its smell was most decided. The firmness of the oleomargarine was due in a great measure to cocoa nut oil.

I thought it would be interesting to examine the action of sulphur chloride on this oil. When cocoa nut oil is dissolved in carbon disulphide and sulphur chloride added, in the same way as previously recommended, it behaves like butter, but on evaporating the carbon disulphide it turns much darker in color. It does not turn cloudy, and dissolves completely in CS_2. A mixture was made of 3 parts cocoa nut oil and 1 part cotton seed oil, and treated in exactly the same way as the cocoa nut oil; it kept perfectly bright and clear.

I find that the addition of a certain quantity of cotton seed oil conceals the taste and smell of cocoa nut oil; but the strong rancid odor of the animal fat which separates from the oleomargarine containing these oils is very pronounced, especially if kept in a warm place for a few hours.

The following will explain the application of this reagent for quantitative results:

	Grammes.
Weight of oleomargarine taken..	5·76
" cotton seed oil added........	5·24
" residue (after treatment with sulphur chloride), etc......	7·74
" due to cotton oil added......	5·67
" increase due to cotton oil in oleomargarine.............	2·07
" cotton oil actually present in oleomargarine........	$\frac{5·67}{5·24} \times 2·07$

= 1·91 grammes = 33·3 per cent.

Two experiments with cotton seed oil alone, as used in this analysis, gave solid residues within 5 per cent. of each other. This difference is much greater than need be incurred after a little practice.

The substance washed out with carbon disulphide was evaporated, and every trace of disulphide removed. Water was added to remove the soluble portion and to decompose any free chloride present, when a dark altered oil or fat floated on the surface, and a white adherent fat stuck to the sides and bottom of the flask; evidently this substance had not been acted on by the chloride. It was in hard white tufts, and smelt strongly of cocoa nut oil.

Cocoa nut oil, in presence of most oils and fats, is not so easily acted on by sulphur chloride, unless in large excess. The altered oils and fats appear to impede the solubility of cocoa nut oil; hence it is quite easy to recover, from the experimental mixture of cocoa nut and cotton seed oils, the cocoa nut oil perfectly white and solid. The procedure was in all respects identical with that given for the quantitative results obtained for oleomargarine.

This portion of the subject is sufficiently interesting and novel, that I hope to deal with it more fully on a future occasion.

A fact which adds importance to this method of testing is that, if cotton seed oil or any similarly affected oil be added to oleomargarine or pure butter, the well-washed solid product obtained is colored by a portion of the animal fats, which is so far pronounced that no difficulty can arise in deciding whether the animal fats are those belonging to pure butter or whether they belong to certain soft fats or oleins.—*Chem. News.*

ALUMINA AS A NATURAL CONSTITUENT OF WHEAT FLOUR.

By W. C. Young, F.C.S.

In a paper read before the society last June, and published in the August number of the *Analyst*, I gave an account of some experiments with the logwood test, the results of which seemed to indicate that alumina was a natural constituent of wheat flour, and, further, that it was confined to the gluten, the starch being quite free from it. In the discussion which followed, our president pointed out that it was generally supposed that alumina was not a natural constituent of wheat flour, and that when found it was ascribed to accidental impurities or purposely added alum. I find also that in the discussion of a paper by Wanklyn at the first meeting of this society, Mr. Allen similarly expressed himself, but Dr. Dupre mentioned that in conjunction with Dr. Odling he had made many analyses of wheat, and had found minute quantities of alumina in every sample.

Recently Yoshida has communicated a paper to the Chemical Society on "Aluminum in the ashes of flowering plants," in which he shows that alumina is a normal constituent of wheat and other cereals.

Soon after the reading of my last paper, I made a quantitative experiment on wheat flour, the result of which not only confirms Yoshida's work, but shows further that the whole of the alumina is contained in the gluten.

The flour used was the best quality Vienna, containing 0·7 per cent. of ash, and as near as I could ascertain about 8 per cent. of gluten. I obtained from 100 grammes of this flour, by a process I shall presently describe, 0·0075 gramme of phosphate of alumina.

The gluten was separated by washing in a muslin bag in the usual way, and when dried contained 1·26 per cent. ash. Twenty grammes of this dried gluten, finely powdered, was then treated with about 250 c. c. of a mixture of equal volumes of acetic acid and water, and heated in the water bath for about twenty-eight hours. By this time the mass had become quite liquid, the gluten having lost its firmness in the same way that gelatin does under similar circumstances. After standing a short time the liquid was poured off, and the sediment further treated with weak acetic acid twice, and the three portions of liquid evaporated to dryness, the sediment being rejected. In this way I think that any extraneous earthy matter present in the gluten was separated, and, therefore, only the natural alumina retained.

The dried residue was then burned to a perfect ash, the ash dissolved in dilute hydrochloric acid and filtered, the insoluble matter being well washed and weighed. The insoluble matter thus obtained weighed only 0·009 gramme, and of this 0·0075 was silica.

The insoluble matter was then fused with about twice its bulk of mixed alkaline carbonates, dissolved in dilute hydrochloric acid, and filtered. This filtrate was added to the acid solution of the ash, evaporated to dryness, redissolved in a small quantity of dilute hydrochloric acid, and filtered. The filtrate was then boiled, and cautiously added to 25 c. c. of a saturated solution of pure caustic soda, also boiling, and the whole kept boiling for a few minutes. It was then filtered, and the precipitate washed, the filtrate made slightly acid with hydrochloric acid, about 5 c. c. of a saturated solution of sodium phosphate added, and finally a slight excess of ammonia. After boiling for about ten minutes, the precipitate of phosphate of alumina was collected and weighed.

I may mention that the process I have just described has been in use for some years now in my laboratory for determining alumina in bread and flour, and is really an improvement on a modification of Normandy's old process which I suggested some years back. The points to be observed as essential to success are: first, the fusion with alkaline carbonates of the ash insoluble in hydrochloric acid, as I have repeatedly found that hydrochloric acid does not dissolve the whole of the alumina in the ash; second, keeping the solutions down to the smallest possible bulk; and third, the employment of a saturated solution of soda.

In this way I obtained 0·0185 gramme of phosphate of alumina from 20 grammes of gluten. Now, as the flour contained 8 per cent. of gluten, and gave originally 0·0075 per cent. of phosphate of alumina, 20 grammes of gluten would be equivalent to 250 of flour, which would yield 0·01875 of phosphate of alumina. So that practically I obtained the whole of the alumina of the flour in the gluten. As in the process of washing the starch from the gluten a large proportion of any earthy matter that may have been present must have been separated, and any remaining eliminated by dissolving the gluten in acetic acid, there can be no doubt that the alumina obtained in this experiment was present as a natural constituent of the flour, and I think further that the interesting fact is established that the bulk of it is associated with the gluten.—*The Analyst.*

THE MANUFACTURE OF COCAINE.

H. T. Pfeiffer gives the following account of his process of manufacturing crude cocaine in Peru and Bolivia.

The disintegrated coca leaves are digested at 70° C. in closed vessels for two hours, with a very weak solution of sodium hydrate and petroleum (boiling between 200° and 250° C.). The mass is filtered, pressed while still tepid, and the filtrate allowed to stand until the oil has completely separated from the aqueous solution. The oil is drawn off and carefully neutralized with very weak hydrochloric acid. A white, bulky precipitate of cocaine hydrochloride is obtained, together with an aqueous solution of the same compound, while the petroleum is free from the alkaloid and may be used for the extraction of a fresh batch of leaves. The precipitate is dried, and by concentrating the aqueous solution a further quantity of the hydrochloride is obtained. Both can be shipped without risk of decomposition. The product is not quite pure, but contains some hygrine, traces of gum, and other matters. Its percentage of alkaloid is 75 per cent., while chemically pure cocaine hydrochloride ($C_{17}H_{21}NO_4.2N.Ch$) contains 80·6 per cent. of the alkaloid. The sodium hydrate solution cannot be replaced by milk of lime, nor can any other acid be used for neutralization. Alcohol or ether is not suitable for extraction. A repetition of the process with once extracted coca leaves gave no further quantity of cocaine, proving that all the cocaine goes into solution by one treatment. The same process serves on the small scale for the valuation of coca leaves. 100 gm. of coca leaves are digested in a flask with 400 c. c. of water and 250 c. c. of petroleum; the flask is loosely covered and warmed on the water bath, shaking it from time to time. The mass is then filtered, the residue pressed, and the filtrate allowed to separate in two layers. The oil layer is run into a bottle and titrated back with $\frac{1}{10}$ HCl (1 gm. of HCl in 100 c. c.) until exactly neutral. The number of c. c. of hydrochloric acid required for titrating back, multiplied by 0·42, gives the percentage of cocaine in the samples. The following are some of the results with different samples of coca leaves of various age:

	Per cent. of cocaine.	
Coca leaves from Mapiri, 1 month old,	0·5	of the weight of the dry leaves.
" " " Yungas " "	0·5	
" " " Mapiri and Yungas, 6 months old,	0·4	
" " " Cuzco (Peru), 6 months old,	0·3	
" " " Mapiri and Yungas, 1 year old,	0·2	
" " " Cuzco, 1 year old,	0·2	
" " " Mapiri and Yungas, 2 years old,	0·15	

Coca leaves from Yungas and Cuzco, 3 years old, contained no trace of the alkaloid, whereas fresh green leaves from Yungas contained 0·7 per cent. of the weight of the dry leaves. The same process is also applicable for the manufacture of quinine from poor quinine bark, with the single alteration that weak sulphuric acid must be used for the neutralization of the alkaloid petroleum extract.—*Chem. Zeit.*

THE CURE OF DEAF-MUTISM.

Whatever may be the disadvantages and dangers of specialism in medicine, no one can dispute that the general sum of knowledge has been vastly increased by the labors of special workers in different departments. Many affections, the nature of which was unknown or misunderstood, have been set forth in their true light, and, being better understood, have come to be more rationally and successfully treated. Deaf-mutism, for example, was formerly regarded as a congenital affliction, and one for which there was no remedy. The labors of otologists have shown, however, that it is frequently due to loss of hearing—the result of ear disease in infancy—and that the deafness so caused is often amenable to cure, or at least improvement, by proper treatment.

In the *Revista de Ciencias Medicas* for December 10, 1887, Dr. D. P. Verdos reports two cases which well illustrate this point. The first case was that of a boy, five years of age, who was a mute. The parents noticed that the child did not begin to talk at the usual age, and after waiting a while in the hope that he might commence to lisp a few words, they consulted their physician. The only explanation that he could offer was that there was probably some trouble with the hearing, which might eventually disappear. After waiting a few years more, and hearing no articulate sound from the boy's lips, they took him to Dr. Verdos' clinic. Examination at this time showed an apparently total loss of hearing. The only hope lay in the fact that the child gave evidence of a slight perception of the sound of the tuning fork applied to the walls of the cranium. Further examination showed that the loss of hearing was due to a catarrh of the Eustachian tube, occurring in infancy, which had caused a closure of its lumen, the rarefaction of the air in the tympanum being evidenced by the enormous retraction of the drum membrane. Treatment was now commenced by catheterization of the Eustachian tube and forcible inflation

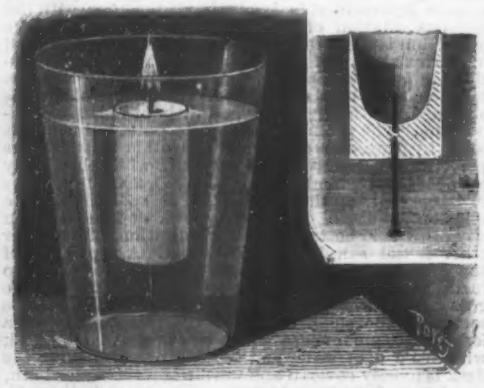
by air douches, assisted by rarefaction of the air in the external auditory canal. By these measures the drum membrane was restored to its normal position, and within the space of two months the boy was able to hear sounds of all kinds, including the ticking of a watch held at some distance from the ear. He soon began to utter a few monosyllables, and rapidly learned to talk with as much ease as any child of his age.

The history of the second case, that of a child four years of age, was similar to the first, though his acquisition of speech was not as rapid nor as perfect, owing, evidently, to mental defect.

These cases are instructive, showing, as they do, that deaf-mutism is not always an irremediable condition, but that, in certain cases at least, proper treatment will save the child from this affliction. They prove, also, that it is not too late to make the attempt to restore the hearing, even after the lapse of several years; and if a child five years old can be saved from this fate, it is not too much to hope that one even older might acquire hearing and speech as a result of intelligent and persistent treatment.—*Medical Record.*

A FLOATING CANDLE.

PUT a short candle which has a tack driven into its lower end into a glass of water. Do not fill the glass so full that the water will flow over the top and wet the wick, which will spoil the experiment. If you now light the candle and announce that the candle will be almost entirely consumed you will scarcely be believed, but such, however, is the case. As the candle is gradually consumed it becomes lighter and lighter, and will soon begin to float. The wax or sperm which is in contact with the water, being kept cool, is not melted, and



A FLOATING CANDLE.

forms a wall which prevents the water from flowing into the cup-like cavity. The candle continues to burn, however, until the wick is almost entirely consumed.

SOME SUGGESTED CHANGES IN THE PATENT LAWS.

To the Editor of the Scientific American:

IN printing my letter to you, in regard to the patent laws and the litigation in regard to patents, in your paper of the 21st Jan., 1888, you did me a kindness, and in your editorial remarks you showed me wherein I had failed to make myself understood, or had failed to express my ideas clearly. I claim that the laws in regard to the issuing of patents should be in many places amended.

One is as to allowing patents to issue for every conceivable change or alteration in a machine or mechanical structure.

One man invents and patents a new machine—one that is competent to do the work designed. It does the work well. Some mechanic, or some man thinking he has a genius for invention, observes some little attachment that is not covered by the patent issued. He changes the shape in some immaterial matter, and applies for a patent for an improvement in the machine. In that application he sets out the whole machine and his device and the combination, and asks for and receives a patent that, on its face and in its drawings, seems to be one covering the whole machine.

He makes and sells these machines, and if any purchaser doubts his right, he brings out his patent, which in its many drawing explanations and combinations seems to cover the whole thing offered for sale.

The purchaser takes the machine home, uses it a while, and the original inventor, by his agent, comes along and demands a royalty for the machine, as it is covered by his patent.

The man has to either pay or be sued, and go to a court, in these Western States, one to two hundred miles from home to defend.

He cannot sit at home and defend a suit. This is what Senator George had reference to. He was talking to Senators, and they knew that arrests as for a crime were not in the law and not contemplated by the Senator.

In order to get a patent, the applicant only makes oath that he is an original inventor and he believes he is the one who first invented that article. But after his invention has been in use, many persons come to see it who know that the same thing was in use long before the time he claims to have invented it.

One who is sued sets up this fact as a defense. These men are called as witnesses, and they are men who, at home, are known to be honest and unimpeachable, but the owner of the invention gets one or two men who will testify that they did not see the article described, and don't believe it was there.

If, by this negative testimony, a doubt can be thrown into the mind of the judge, he, under the ruling of many of our circuit courts, must hold that prior use is not proved, for the party offering that as a defense must remove all reasonable doubt. That is, the owner of a machine that he purchased in an open market, made by a man who had a patent issued by the United States government, when his right is attacked by another claiming under a patent issued by the same authority, must prove that he is not guilty by evidence that removes from the mind of the court all doubt, as some courts have held, and others all reasonable doubts.

That is, to defend himself in a civil suit, he must prove his innocence by as strong testimony as the state would have to prove his guilt, if it accused him of a crime. This is not right. The rights of the people should be protected, and not alone the rights of the patentee, especially when the Patent Office is allowed to issue from 150 to 200 patents covering the same article. You say, "If innocent purchasers of patented articles should be protected, then protection for the innocent accessories of thieves should be provided."

Is there no difference between the man who gets a patent for an improvement upon a machine and one who steals property? If not, then certainly the government should be prohibited from issuing patents for these improvements.

The hardship is not like that suffered by one who purchases stolen goods. No person is justifiable in buying of a stranger under circumstances that are suspicious as to the title of the property.

But when the United States puts out a document giving the right to from twenty to two hundred different persons to make, vend, and use machines that are intended to accomplish the same end, do the same work, and are used for the same purpose, and in which the variation is exceedingly small, the man who buys of either his machine or article ought not to be liable to some other man for a royalty because the maker of his machine has made some part of it like the machine that some one else has a patent for. Yet these suits do occur, and defendants are put to great expense in defending themselves against such actions.

Thus if you attach to your house and lot some article, and I rent the house of you, and use the article as a part of the premises rented, I ought not to be subject to pay a royalty to some one who claims that he has a patent on that article.

Yet the United States circuit courts have held that I must pay such royalty. There are many other abuses that have grown into our patent system that I have not time to enumerate now. But these I am sure need remedying. By giving this place in your paper, it may open the eyes of others to the defects in the laws and decisions of our courts, and will confer a favor on JED LAKE.

Independence, Iowa, January 25, 1888.

A NOVEL exhibition has been going on at the Paris Hippodrome, during the winter, which has greatly interested the Parisians. A line of railway runs round the arena, upon which a locomotive with carriages steams along at considerable speed. The train is filled with French troops, who respond to the fire of a company of Arabs, and an animated contest is carried on for some time. Finally, the Arabs are defeated and the wounded are carried to the ambulance car of the train, and the locomotive gets up steam and runs out of the arena. The maneuver between the French soldiers and the Arab warriors is said to be very interesting and exciting to the spectators.

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